APS Journals Style Guide for Authors

(May 2024)

APS Journals Style Guide

I. Introduction

This notation guide represents a compendium of general *Physical Review* style rules to help authors when preparing a paper for submittal. It is highly desirable for notation to be consistent and to adhere to standardized form so that all papers can be processed efficiently throughout the publication cycle. Both the editorial staff and the production staff appreciate your effort to follow our style, which will help us get your paper posted and published more efficiently. Accuracy will be improved, as properly prepared manuscripts will eliminate the need for excessive manipulation of the manuscript file or rekeying the entire paper, which may introduce unintentional errors.

Please note that as part of the production process, APS converts all article files, regardless of their original source, into standardized XML code that in turn is used to create the PDF and online versions of the article as well as to populate third-party systems such as Portico, CrossRef, and Web of Science. We share our authors' high expectations for the fidelity of the conversion into XML and for the accuracy and appearance of the final, formatted PDF.

This guide has been arranged so it can be used as a reference manual. Specific journals may have differences or exceptions to the general instructions provided here, which may be conveyed to the author by the appropriate journal editor. Authors should also consult the Information for Authors document found under the Authors link on the *Physical Review* journal homepages.

II. Style Instructions for Parts of a Manuscript

A. Title

Titles should be self-contained, simple, and concise. Nonstandard abbreviations, acronyms, and terminology should be avoided. Do not use unnecessary words (a, on, an, the, etc.) at the beginning of the title.
See also Titles

For RMP, PRA, B, C, D, E, PRApplied, PRResearch, PRAB, PRFluids, PRMaterials, and PRPER: Initial caps (sentence case)—begin the first word, and that following a colon or

M dash, with a capital letter; thereafter capitalize only proper or trade names and chemical symbols.
Note also for RMP: There is a ten-word limit on the titles of articles.

For PRL, PRX, PRX Energy, PRX Life, PRX Quantum: Title case—capitalize the first letter of each word except for conjunctions, prepositions, and articles (unless a colon or M dash precedes).

B. Author names and byline footnotes

1. Author names

Author names may be listed in any order in the byline between the title and abstract. If the number of authors exceeds 40, the authors will be listed in the Table of Contents as, e.g., A. Jones *et al*. It is also permitted to give a group (Collaboration) name in addition to the single full list of author names. The group name is put in parentheses, between the end of the list of authors and the beginning of the list of institutions. If the number of authors exceeds 40, the group name will appear in the Table of Contents.

In general, first name or first initial and last name are required. Middle name or initial(s) may be included. For effective indexing and identification, full first names are recommended, and the same form of author name should be used in all publications (e.g., not A.L. Smith in one and Ann Smith in another paper).

Chinese, Japanese, and Korean authors can choose to display their names in their native glyphs alongside the English versions of their names.

Authors who undergo a name change during their career, may wish to have a byline footnote that states "Formerly _____." with the previous full name listed for ease of recognition and search capability (see also APS Name Change Policy). We also encourage the use of ORCIDs to link authors to their research.

2. Byline footnotes

Contact footnotes to an author's name are intended to facilitate locating or communicating with an author, for example, by indicating that an author's address has changed either temporarily or permanently.

Possible footnote content indicators:

Also at

Also xxx Department

Contact author: author@email

Deceased.
Fax:
Formerly (known as)
Guest scientist (from)
Lead author.
Lead and contact author.
On leave (assignment) from (at)
On sabbatical leave from
Permanent address:
Present address:
Present and permanent address:
Principal author.
Retired.
Summer visitor (from)
These authors contributed equally to this work.
Visiting scientist (from)
Visitor from
[Collaboration] Spokesperson. (e.g., PHENIX Spokesperson.)
Group Spokesperson.

Author email addresses, URLs, and/or personal pronouns can be given without a content indicator, for example,

* author@email.com
† author@email.com, they/them/theirs
‡ she/her/hers
§ he/they
‖ https://www.authorwebsite.com

More than one email for the same author:

* author@email1.com, author@email2.com

When an email address is given with a content indicator, use a colon after the indicator and no line break, for example,

*Group Spokesperson: author@email.com

Footnotes should end with a period, except for email addresses and URLs. Addresses included in footnotes should follow the same style as affiliations: Department,

Institution, City, State, Post code, Country. (State names may be abbreviated in byline footnotes.)

Examples:

*Deceased.
†Also at Department of Physics, The Ohio State University, Columbus, OH, USA.
‡ author@email.com

a. Author contribution

As an option, the statement "These authors contributed equally to this work." may be set as a byline footnote, with an appropriately chosen byline footnote indicator. More detailed information about the division of responsibilities should be placed in a separate paragraph after the Acknowledgment section (e.g., "A. Z. and B. Y. conceptualized the work; C. X. conducted the experiments.").

See also section on Author contributions and alphabetical ordering of authors

b. Contact author(s)

Footnotes giving email addresses of one or more post-publication **contact authors** are strongly encouraged:

Contact author: author@email

Note that these footnotes are not included automatically. If more than one contact author is provided, place each on a separate line:

Contact author: author1@email
Contact author: author2@email

c. Deceased

Names of authors who passed away before or during the review process should carry a footnote stating "Deceased." Coauthors should notify the editors before publication. Therefore readers will be informed should they attempt to make contact after publication. In addition, as an option, a *Note added* section can be added, such as

> *Note added.* While this manuscript was under review, one of the coauthors, John Smith, passed away.

3. Byline footnote style and location

If there are 12 or fewer footnotes, use superscript symbols to author names and affiliations in the order *, †, ‡, §, ‖, ¶, **, † †, ‡ ‡, § §, ‖‖, ¶¶. Use lowercase italic letters *a*, *b*, *c*, etc., if there are 13 or more footnotes.

For all journals except PRL: The footnote material will appear at the bottom of the page on which the footnote superscript indicator appears. Usually, this is the first page of the paper.

For PRL: The footnote material will appear as the top of the reference list at the end of the paper.

C. Affiliations of authors

Authors should provide a complete list of the institutions where their research was performed. Affiliations not connected with the research in the paper should not be included. If an author is not affiliated with any institution, they may provide a home address. If the author is retired, a byline footnote can also be added: *Retired. An address is required for each author.

Byline addresses should consist of department or division, institution, city, state (if relevant), and country, in this order. Street addresses, post office boxes, ZIP or postal codes, etc., are not required but may be included. Institutions can be anglicized or appear in the language of the respective country (Latin characters only).

For all journals except RMP:
Affiliations can be presented in two ways.

(a) Each address can be listed directly below the author(s) at that address.

(b) A superscript number can be set after each author name in the author list, and correspondingly before that author's address. The addresses are collected in a list below the authors; each address is listed separately.

Examples:
(a)
John Carter
Max-Planck-Institut für Physik komplexer Systeme, Dresden 01187, Germany
and Department of Physics, The University at Buffalo, Buffalo, New York 14260, USA

Beth Silverstein
The James Franck Institute, The University of Chicago, Chicago, Illinois 60637, USA

(b)
John Carter[1] and Beth Silverstein[2]
[1] Max-Planck-Institut für Physik komplexer Systeme, Dresden 01187, Germany

and Department of Physics, The University at Buffalo, Buffalo, New York 14260, USA

[2]The James Franck Institute, The University of Chicago, Chicago, Illinois 60637, USA

(This format is recommended in cases where a particular author order is desired.)

For RMP:
Use form (a) only.

For Collaborations in all journals: use form (b). Example:

John F. Horton, Jr.,[1] James E. Peterson,[2] Albert S. Rudolf [3]
(ATRAP Collaboration)

[1]Department of Mechanical Engineering, University of Florida, Gainesville, Florida 32622, USA

[2]Center for Bio/Molecular Science, Naval Research Laboratory, Washington, DC 20375, USA

[3] IKP, Forschungszentrum Jülich GmbH, 52425 Jülich, Germany

D. Receipt date

The receipt date indicates the date the manuscript was received by the editorial office through the submissions server. This date will be verified by the editor and will appear in the published article. Usually, manuscripts transferred between Physical Review journals will retain the original receipt date. If authors make substantive changes to the manuscript during the review cycle, a revised date may be assigned. In cases of major delays or changes, a resubmitted manuscript may be given a new receipt date.

For RMP: There is no receipt date.

E. Abstract

Abstracts should concisely summarize the subjects, conclusions, and results of the manuscript. In the abstracts of experimental papers, specify the quantities measured and objects studied and clearly describe the experimental conditions. Avoid coined words and unexplained acronyms (spell out acronym if used only once; define at first use if used more than once). Displayed equations and tabular material are not permitted. Abstracts should consist of one paragraph and be completely self-contained, as abstracts are

presented separately from the rest of the paper in other venues. Abstracts cannot contain numbered references; incorporate source listings directly into the abstract text itself.

Example:

We achieve this by generalizing a prescription by Lee [Phys. Rev. A 44, R2775 (1991)] ....

Physical Review C encourages authors to prepare a structured abstract that contains sections summarizing the paper's background, purpose, methods, results, and conclusions (see PRC's September 2011 Editorial for the rationale and an example).

Note that Comments and Replies submitted to PRL do not require abstracts. Errata do not require abstracts.

Abstract length limits: about 5% of article length and < 500 words for all journals except PRL, which allows ≤ 600 characters.

F. Table of Contents

A Table of Contents (TOC) may be used for long and/or complicated regular articles at the Editor's discretion. Please ensure that section headings (which will be used to generate the TOC) conform to journal style (see below).

For "Tutorial" articles, a TOC may be used but is not required.

For RMP
Review articles require a TOC. Every titled section and subsection of the paper will be listed in the TOC.

G . Sequential organization of the paper

The body of the paper (text and math) may be divided into sections with the use of section headings and subheadings. However, note that headings are not always required; for short papers headings may not be necessary or permitted. Equations, tabular material, figures, and references should follow a sequential numerical scheme in order to ensure a logical development of subject matter.

1. Types of headings and section-head numbers

The major divisions in a regular article are indicated by principal headings [level (1)]. Each major section can be further divided by subheadings [levels (2)–(4)]. Each subdivision of a heading indicates a more specific topic. The following list indicates the four different types of section headings and the appropriate style for each. In all headings, symbols and abbreviations should appear as they would in text. Note that headings are

not always required and for short papers headings may not be necessary. Refer to a recent issue of your journal for comparison.

See also section on Appendixes for how to style Appendix headings.

See further below for divisions in a *Physical Review Letters* paper.

a. All journals except RMP and PRL

i. Regular Articles

Level (1)

I. PRINCIPAL HEADING

Standalone bold centered heading, all capital letters, preceded by a roman numeral and a period.

Level (2)

A. First subheading

Standalone bold centered heading, first word capitalized, preceded by a roman capital letter and a period.

Level (3)

1. Second subheading

Standalone bold centered heading, first word capitalized, all italic, preceded by an arabic numeral and a period.

Level (4)

a. Third subheading. Text following a paragraph indentation, first word capitalized, all italic, preceded by a lowercase letter.

Theorem 1. Theorems, Definitions, Lemmas, Proofs, etc., are introduced in text as single words (and numbers or letters as appropriate) as level (4) headings, italic with paragraph indent followed by a period, full space, then roman text follows.

Theorem 1. Roman text....
Corollary 1. Roman text....
Proof of Theorem 1. Roman text....
Definition. Roman text....

If a further level is used, follow with a colon and a full space.

Proof of Theorem 1. Roman text....
Step 1: Roman text....
Step 2: Roman text....
Step 3: Roman text....

These elements are numbered individually and sequentially, such as Theorem 1, Theorem 2, Definition 1, Definition 2, etc. Proof elements are usually unnumbered.

Extra line spacing is permissible in group theorems, etc., together as needed, to set them off.

Squares to indicate the end of a proof should be solid black squares set flush right.

ACKNOWLEDGMENTS

Style as principal heading but with no number. Use ACKNOWLEDGMENT if a single thing is being acknowledged.

If a paper has no headings, the acknowledgments are set apart by a blank line.

ii. Letters

Section headings are optional, but when they are used, use a level 4-style heading: Italic font, paragraph indent, first word capitalized, ending with a period, but no preceding letter, e.g.,

> *Introduction.* Analogies between physical phenomena arise…
>
> *2D harmonic oscillator.* The 2DHO obeys the Schrödinger...
>
> *Acknowledgments.* We thank…

b. RMP

Level (1)
I. PRINCIPAL HEADING
Standalone bold heading set flush left, all capital letters, preceded by a roman numeral and a period.

Level (2)
A. First subheading
Standalone bold heading set flush left, first word capitalized, preceded by a roman capital letter and a period.

Level (3)
1. Second subheading

Standalone bold heading set flush left, first word capitalized, preceded by an arabic numeral and a period.

Level (4)
a. Third subheading
Standalone lightface italic heading set flush left, first word capitalized, preceded by a lowercase letter.

or

Third subheading:

without an enumerative letter, following a paragraph indentation, first word capitalized, all italic, followed by a colon.

c. PRL

Third subheading. —Text follows here

Freestanding heads are not generally used in PRL. Use a Level (4) style heading (third subheading). Italic font, paragraph indent, first word capitalized, ending with a period and M dash. Text follows. PRL does not use a heading for the acknowledgment section.

If a further level is used, follow with a colon and an em space.

Global fit: Text….

Theorems, Lemmas, Proofs, etc.
Single words used within the text of Theorems, Lemmas, Proofs, etc., can be italic at their first appearance, as is usual PRL style, but several sentences or paragraphs should not be italic or bold.

Headings and Text
Headings should be treated as run-in heads (paragraph indent, italic head, followed by period and em dash).

Theorem 1.—Roman text....
Corollary 1.—Roman text....
Proof of Theorem 1.—Roman text....
Definition.—Roman text....

Step 1, Step 2, etc., when used, are indented with a paragraph indent, roman, colon, em space, followed by roman text.

Proof of Theorem 1. — Roman text....
Step 1:[em space]Roman text....
Step 2:[em space]Roman text....
Step 3:[em space]Roman text....

Extra line spacing is permissible in group theorems, etc., together as needed, to set them off.

Squares to indicate the end of a proof should be solid black squares set flush right.

2. References, footnotes, and endnotes

a. All journals except RMP

References (citations of other work) and endnotes (subsidiary remarks) are combined in a single list and placed at the end of the paper. They should be designated by online arabic numerals enclosed in square brackets and should be numbered consecutively in order of their first appearance in text. All sources should appear in the reference list, including URLs, which should not appear in the body of the paper.

Also, as an option for *PRA, PRB, PRC, PRD, PRE, PRAB, PRFluids,* and *PRPER:*

Subsidiary remarks may appear as footnotes placed at the bottom of the page on which they are cited. (This option works best for short remarks.) They should be designated by superscript arabic numerals and numbered consecutively throughout the paper.

b. RMP

i. Citations in text

Citations of other work are identified by author names and year of publication.
All forms use parentheses, depending on placement in text. Here are some examples:

(1) The object N 157B in the Large Magellanic Cloud shows a filled center and nonthermal spectrum at both radio and x-ray wavelengths (Clark et al., 1982).

(2) The interested reader will find good discussions of much of this work in Potter (2000), Hockney and Eastwood (2001), and Birdsall and Langdon (2005).

(3) The field of nonlinear transport, which had been initiated long before by a few pioneer papers (Landau and Kompanejez, 1934; Davydov, 1936, 1937), then entered a period of rapid development.

(4) The constant *C* can be obtained from Cohen and Keffer (1955; see also Osheroff *et al*., 1980, and Roger,1980).

In example (1), *et al*. has been used, signifying that there are three or more coauthors. Note that the names of all coauthors will be presented in the list of references at the end of the paper. However, certain citations arise for which it
would be preferable to name the coauthors in the text as well; for example, say two papers by Clark and co-workers were listed in the references for 1982, one by Clark, Jones, and Smith, and the other by Clark, Lewis, and Jones. These citations could not be labeled 1982a and 1982b because they are not by the same group.

In example (2), only the year of the reference appears in parentheses. It is unnecessary to repeat the author's name in parentheses when the name already appears as part of a sentence.

In example (3), a list of references is given within parentheses. Note that the citations are arranged chronologically, with the earliest first, and that a semicolon separates each citation. In a list that contains more than one
work appearing in the same year, the citations should be arranged alphabetically by authors' names. Commas separate authors' names from years. When more than one work by the same author is cited, the years are
separated by commas. No “and” is used before the last citation.

ii. Citations as footnotes

Authors are encouraged to put long lists of citations in footnotes that will be set at the bottom of the page. This placement allows the flow of the text to be less disturbed. Note that single citations should always be placed in the text.

As material in footnotes should be in note form and not just a list, the citations should appear as part of a sentence. Truncated examples follow.

[1] For historical background on this problem, see Adams and Withey (2001, 2005) …

[2] A number of theorists have proposed alternatives to this model that we shall not discuss here. They include …

[3] See, for example, …

iii. Subsidiary remarks as footnotes

Footnotes (subsidiary remarks) appear at the bottom of the page. They should be designated by superscript arabic numerals and numbered consecutively throughout the paper.

3. Figure and table numbering

In the body of the paper, all figures and tables should be numbered in the order in which they are cited in text. The numbering is consecutive throughout the whole paper,

including the Appendix or Appendixes. Do not number figures and tables according to the section in which they appear.

Figures use arabic numerals (1, 2, 3, etc.) with (a), (b), (c), etc., to label the parts of figures. Note that parentheses are used to enclose the labels for parts of figures, e.g., Fig. 1(a). For figure citations, use "Figure" at the beginning of a sentence and "Fig." elsewhere.

Tables are numbered with roman numerals (I, II, III, etc.). Although it is uncommon, letters enclosed in parentheses can be used to identify table parts [Table II(a), e.g.]. There is no abbreviation for table citations.

4. Equation numbering

Equations that are important, long, complex, and/or referenced later in the paper are set off from the text, or displayed. They may be numbered by arabic numerals continuously throughout the whole paper [e.g., (1), (2), etc.] or numbered according to the main section in which they appear. For classifying by section, number according to the section labeled by a principal heading (I, II, etc.), but change the roman numeral to its arabic equivalent [e.g., (1.1), (1.2), etc.].

Appendix equations are an exception to the rule noted above. They are numbered separately from equations appearing in the main body of the paper. The equation number contains a capital roman letter identifying the appendix in which the equation appears. If there is only one appendix, the equation numbering is (A1), (A2), (A3), etc. For more than one appendix, each appendix section heading will be labeled A, B, etc., and the equation numbering should be (A1), (A2), (A3), etc., (B1), (B2), (B3), etc.

Similar equations can be grouped together by using equation numbers with lowercase roman letters a, b, etc., added to the main equation number. There are two categories of such equations:

(1) A set of equations of equal importance may be labeled to demonstrate that relationship, e.g., (1a), (1b), and (1c).

(2) A principal equation and subordinate equations (those that define quantities or variables in that equation) may be numbered (1), (1a), and (1b), etc.

If an equation is a variant of a previous equation (it could be separated from the original equation by other equations and/or by text), it may be numbered with the same number as the original and a prime, double prime, etc., as appropriate (one prime means first variation, double prime means second variation, etc.), e.g., (1), (2), (1′).

Equation numbers are placed flush against the right-hand margin and are aligned with the equation's last line or centered for a group of equations.

H. *Note added* section

Authors may add a paragraph to make contact with recently found related work not mentioned in the body of the paper, either after the manuscript was written (as a *Note added*) or during the proof check process (as a *Note added in proof*). The paragraph should be placed after the final section of the paper, before the Acknowledgment, if any, and before any data availability statement and/or Appendixes. It is introduced by a fourth-level heading (italicized and run into text).

Note added. Recently, we became aware of another related time-of-flight investigation with Er and Dy atoms [26].

(PRL uses *Note added.*—)

If the *Note added* is longer than one paragraph, the heading becomes a third-level standalone head:

Notes added

Recently, we became aware….

Another recent work is in alignment with the calculations …

Historical reference points are not permitted, therefore do not use such statements as "During the preparation of this paper… ."

This section should not be used for additional discussion of material previously presented. Such text should be relocated to an appropriate section.

If an author passes away during the history of the paper, mention can be made in the paper as follows:

Note added. While this manuscript was under review, one of the coauthors, John Smith, passed away.

(here, reference to the timeframe is acceptable)

It is also customary to include a byline footnote for the author who passed away, stating "*Deceased."

I. Data availability and research data statements

Data availability statements provide information about accessing the data that support the results reported in the research paper. The *Physical Review* journals strongly encourage authors to share relevant data, code, software, and other materials that support their reported results, either by depositing them in open data repositories at the time of publication or by providing them upon reasonable request. Delays in sharing these materials may be appropriate in certain circumstances in order to respect privacy, trade secrets, or national security. In addition to these recommendations, authors should follow requirements for sharing data and code set by their funding agencies.

The statement is placed as a separate paragraph before the Acknowledgments, without a heading and a line space above and below for separation. A reference to the data should be added to the reference list and cited in the statement. The reference should include the authors (creators) of the data, the year, any version number, the name of the repository (if applicable), and a persistent identifier, preferably a DOI. If the data have a corresponding article published in a data journal such as Scientific Data, then the reference to the journal article should be included as well.

Examples:

- In accordance with the EPSRC policy framework on research data, access to the data will be made available [31].

[31] A. Coldea and M. Watson, 2015, 10.5287/bodleian:q524jn76v.

- The supporting data for this article are openly available from the University of Bath data archive [44].

[44] Robert Jack and Ian Thompson, 2015, University of Bath Research Data Archive, 10.15125/BATH-00153.

- The Department of Energy will provide public access to these results of federally sponsored research in accordance with the DOE Public Access Plan [35].

[35] https://energy.gov/downloads/doe-public-access-plan

- The supporting data for this Letter are openly available from the NASA Space Physics Data Facility [54–61]. Additional SWEAP data and information are available at the SWEAP web page [62].

[54] J. C. Kasper, M. L. Stevens, A.W. Case, and K. E. Korreck, PSP Solar Wind Electrons Alphas and Protons (SWEAP) SPC Ion Number Density, Velocity, and Thermal

Speed Moments and Fits, Level 3 (L3), 0.2185 s Data, [Data set], 2020 data, NASA Space Physics Data Facility, 10.48322/49we-tr31.

[55] J. C. Kasper, M. L. Stevens, A. W. Case, and K. E. Korreck, PSP Solar Wind Electrons Alphas and Protons (SWEAP) SPC Ion Number Density, Velocity, and Thermal Speed Moments and Fits, Level 3 (L3), 0.2185 s Data, [Dataset], 2020 data, NASA Space Physics Data Facility, 10.48322/ 49we-tr31.

Data statements that do not include a reference:

Statements about data or the lack of research data without references or citations of other sources should also be given in a separate paragraph before the Acknowledgment section. In these cases, no references are needed.

- In compliance with EPSRC policy framework on research data, this publication is theoretical work that does not require supporting research data.
- In accordance with UK research data policy, all data accompanying this publication are directly available within the publication.

J. Acknowledgments

The Acknowledgment section should be used for the recognition of those contributing individuals and institutions who might otherwise go unnoticed. However, not all types of acknowledgments are appropriate for the Physical Review family of journals, even though they may be quite appropriate for an internal report or for a Ph.D. thesis.

For example, we do not include acknowledgments to those who may have helped in the preparation of the manuscript itself (administrative assistants, etc.), or to those who contributed general encouragement or moral support (family, friends, etc.) or services that were not directly a part of the research (grant coordinators, budget directors, etc.). We also do not print notices of fulfillment of requirements for theses.

If desired, use of an AI-based writing tool may be noted in the acknowledgments. Please see APS's policy on Appropriate Use of AI-Based Writing Tools.

Examples of suitable acknowledgments are thanks to other scientists for scientific guidance given in discussions or by the communication of results, mention of technical

assistants who helped in the actual research, and citations of funding agencies that sponsored the work. Acknowledgments to individuals should be a simple statement of thanks for help received and not a dedication or a memorial.

Memberships, positions, titles, and awards may be mentioned in acknowledgments only if they are sources of funding for the research presented and the financial support is stated explicitly. For example, say “A.B. acknowledges support as a Guggenheim Fellow,” but do not say only “A.B. is a Guggenheim Fellow.”

Use initials of authors to indicate support statements, not full names. However, for papers with Collaborations or a lengthy author list, it is permissible to use full names.

K. Author contributions and alphabetical ordering of authors

Information concerning contributions and alphabetical ordering of authors should not be included in the Acknowledgment section but placed in a separate paragraph after the Acknowledgment section, with no heading and a line space above and below.

Statements of equal contributions may be given here (e.g., “A.B. and C.D. contributed equally to this work.”), as well as a list of brief individual responsibilities (e.g., “A.Z. and B.Y. conceptualized the work; C.X. conducted the experiments.”).

As an option, the statement “These authors contributed equally to this work” may be set as a byline footnote, with an appropriately chosen byline footnote indicator.

Statements regarding the ordering of author names should be placed here as well, as the last paragraph of the section (“The authors of this paper were ordered alphabetically.”)

L. Conflict of interest statements

Authors may provide a conflict of interest statement, which should be placed in a separate paragraph after the Acknowledgment section (and after any author contribution statements) with no heading and a line space above and below.
This applies to specific information (e.g., “D.E. has an equity interest in Optofluidics, Inc.”) and null content information (“The authors declare no competing financial interest.”)

Example:

- The University of Minnesota has equity and royalty interests in Niron Magnetics LLC. These interests have been reviewed and managed by the University of Minnesota in accordance with its Conflict of Interest policies.

- The funding bodies played no role in the design of the study, collection, analysis, and interpretation of data and in writing the manuscript.

M. Disclaimers and government remarks

Statements such as disclaimers, equipment nonendorsement, license to reproduce, not subject to U.S. copyright, government contribution or document numbers, etc., should be set in a single paragraph after the Acknowledgment with no heading, a line space above and below, and after any paragraphs for author contributions and conflict of interest.

N. Human and animal research ethics statements

This information should be placed at an appropriate place in text, usually where the methods of collecting data are described.

Research involving experiments with human or animal subjects should conform to ethical standards outlined in the Uniform Requirements for Manuscripts Submitted to Biomedical Journals from the International Committee of Medical Journal Editors. The relevant section is II.F., Protection of Research Participants.

When reporting experiments on human subjects, authors should indicate whether the procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the ethical principles outlined in the World Medical Association Declaration of Helsinki with all current revisions and amendments. When applicable, institutional review board approval should be indicated in the manuscript. Also, the manuscript should describe the manner in which informed consent was obtained from any human subjects. When reporting experiments on animals, authors should indicate whether the institutional and national guidelines for the care and use of laboratory animals were followed.

O. Appendixes

Appendixes are placed after the acknowledgments section and before the listing of references. All appendixes should have a heading [level (1)]. Several formats are permitted; examples of each appear below.

APPENDIX
(single appendix, no subtitle)

APPENDIX A
(more than one appendix, no subtitles)

APPENDIX: SURVEY OF RESULTS
(single appendix with subtitle)

APPENDIX A: SURVEY OF RESULTS
(more than one appendix with subtitle; all must be subtitled).

Subheadings within an appendix:

1. First subheading (level 2)
a. Second subheading (level 3)
i. Third subheading. Text…(level 4)

Displayed equations in appendixes are numbered separately from those in the main body of the paper. These equations are numbered consecutively [(A1), (A2), (A3), etc.], bearing the label of the appendix in which they appear [e.g., (A1), (B1), (C1)]. For the case of one appendix, use the (A1), (A2), (A3) form for numbering equations.

Figures and tables follow sequential numbering from the body of the paper.

Appendixes should not consist of only figures or tables or diagrams without any accompanying explanatory text and citation of these elements.

P. Footnotes

There are three categories of footnotes: Footnotes to front matter information (authors and affiliations, see Byline footnotes); footnotes for subsidiary remarks or short comments relevant to the text material; and table footnotes.

1. Front-matter footnote style and location

The order to be used for superscript symbols for footnotes to author names and affiliations is *, †, ‡, §, ‖, ¶, **, † †, ‡ ‡, § §, ‖ ‖, ¶¶ if there are 12 or fewer footnotes. Use lowercase italic letters *a*, *b*, *c*, etc., if there are 13 or more footnotes.

Generally, such footnotes are used to indicate the author to whom correspondence should be addressed, or an author's present address, for example.

For all journals except PRL: The footnote material will appear at the bottom of the page on which the footnote superscript indicator appears (usually this is the first page of the paper.

For PRL: The footnote material will appear as the top of the reference list at the end of the paper.

2. Subsidiary remarks as footnotes

For RMP, PRA, PRB, PRC, PRD, PRE, PRAB, PRFluids, PRPER: Footnotes may be used for short comments or subsidiary remarks to text material. The footnote indicators are designated by superscript numerals and are numbered consecutively throughout the paper. When punctuation is present at the point where a footnote is cited, place the superscript number *after* commas, periods, and quotation marks, but *before* colons and semicolons. The footnote material is set at the bottom of the page on which the superscript footnote number appears.

3. Table footnotes

These footnotes pertain only to a particular table and do not appear in any other list. These footnotes are used for citations of references or extra information of tabular material. Do not set a footnote to the caption; add the information to the caption itself.

The style for citation of references in table footnotes is as follows:

If the reference is in the reference list, use the format:

Author last name(s) [cite] e.g.,

- Smith and Brown [2].
- Smith *et al.* [1]. (More than two names.)

or

- Reference [2].

If the reference only pertains to the table and is not in the reference list, use the full reference citation, e.g.,

- M. Smith and K. Brown, Phys. Rev. A 79, 032510 (2009).

For all journals: Use lowercase roman letters a,b,c, etc., as the footnote indicators to headings and entries inside the table. The footnote material is placed below the final rules of the table. The footnote indicators should be lettered consecutively row by row, and not by column.

Q. Reference List

1. Format of List

a. All journals except RMP

Sources (papers and material published in journals, books, and conference proceedings, e-prints, theses, personal communications, unpublished papers, and webpages) are set in a list at the end of the paper. The citations of these sources, or references, are numbered consecutively in order of appearance in text and set in square brackets.

b. RMP

The references in RMP papers are arranged alphabetically by author. As the references are not numbered, citations in text must be identified by authors' names and year of publication. See section on References, footnotes and endnotes in RMP for examples of citations in text. See RMP reference list style for reference list examples.

Note that references to papers published in peer-reviewed journals are considered primary references. References to e-print archives should not be used in place of primary references.

General styles for reference elements are listed below.

2. Titles of papers in references

Titles of articles for journal articles, e-prints, and other sources are encouraged in the reference list.

For PRX, PRX Energy, PRX Quantum, PRX Life, PRResearch, PRApplied, and PRFluids:
Titles in references are required for all sources.

For PRL, PRA, PRB, PRC, PRD, PRE, PRAB, PRMaterials, and PRPER:
Titles in references are encouraged, but if chosen, titles should be provided for all eligible references.

a. All journals except RMP

Titles should be styled with a capital letter at the beginning of the first word, initial cap format. Roman typeface should be used, without quote marks. Follow APS journal style for treatment of quantities and symbols.

Examples:

P. A. Krachkov, R. N. Lee, and A. I. Milstein, High-energy e^+e^- photoproduction in the field of a heavy atom accompanied by bremsstrahlung, Phys. Rev. A **90**, 062112 (2014).

T. K. Chan, Y.-H. Sham, P. T. Leung, and L.-M. Lin, Multipolar universal relations between *f*-mode frequency and tidal deformability of compact stars, Phys. Rev. E **90**, 124023 (2014).

C. Stehle, C. Zimmermann, and S. Slama, Cooperative coupling of ultracold atoms and surface plasmons, Nat. Phys. **10**, 933 (2014).

b. RMP

RMP uses short and long options (i.e., titles given all-or-nothing on a single paper). Titles should be styled with a capital letter at the beginning of the first word. Roman typeface should be used, with quote marks. Follow APS journal style for treatment of quantities and symbols.

Example:

Reinert, F., G. Nicolay, S. Schmidt, D. Ehm, and S. Hüfner, 2001, "Direct measurements of the *L*–gap surface states on the (111) face of noble metals by photoelectron spectroscopy," Phys. Rev. B **63**, 115415.

3. Author names in references

Initials for first and middle names (separated by a full space) or full names are acceptable. List all names for a source. If there are more than 20 authors, use *et al*. (italics) after the first name.

Provide all names for references with up to ten authors. For more than ten authors you may use First Author *et al*., but up to 20 names are allowed before *requiring* the use of First Author *et al.*

For collaborations, use the format

More than 20 authors:
J. M. Smith *et al*. (XYZ Collaboration)

Less than 20 authors:
C. E. Aalseth, P. S. Barbeau, J. Colaresi, J. I. Collar, J. Diaz Leon, J. E. Fast, N. E. Fields, T. W. Hossbach, A. Knecht, M. S. Kos, M. G. Marino, H. S. Miley, M. L. Miller, J.L. Orrell, and K.M. Yocum (CoGeNT Collaboration), Phys. Rev. D **88**, 012002 (2013).

4. Journal articles

Use the standard abbreviation for journal title. We follow the Chemical Abstract Service Source Index (CASSI) guide. Go to the CAS Source (CASSI) Source Tool to search for the appropriate abbreviation [https://cassi.cas.org/search.jsp].

Set the volume number in boldface font. We use the first page only, not a range of pages, in the source listing.

Examples:

C. Nadal, S. N. Majumdar, and M. Vergassola, Phys. Rev. Lett. **104**, 110501 (2010).
[published]

F. Izumi and T. Ikeda, Mater. Sci. Forum **321–324**, 198 (2000).
[volume range]

S. Patitsas, Am. J. Phys. (to be published).
[paper is accepted for publication in a journal]

K. C. Schwab and M. L. Roukes, Phys. Today **58** (7), 36 (2005).
[issue number enclosed in parentheses]

C.-H. Zhang and U. Thumm, Phys. Rev. Lett. **102**, 123601 (2009); **103**, 239902(E) (2009).
[Erratum designated with (E)]

J. M. Kosterlitz and D. J. Thouless, J. Phys. C **5**, L124 (1972); **6**, 1181 (1973).
[same authors, two articles in same journal]

H. Min, R. Bistritzer, J. J. Su, and A. H. MacDonald, Phys. Rev. B **78**, 121401(R) (2008); T. Stroucken, J. H. Grönqvist, and S.W. Koch, J. Opt. Soc. Am. B **29**, A86 (2012).
[Rapid Communication designated by (R); two sets of authors; two articles in different journals]

V. Efimov, Yad. Fiz. **12**, 1080 (1970) [Sov. J. Nucl. Phys. **12**, 589 (1971)].
[Russian journal reference with English journal translation]

F. Verstraete and J. I. Cirac, J. Stat. Mech. **2005,** P09012; D. Harlow and P. Hayden, J. High Energy Phys. **2013**, 8.5 (2013); C. Savage, G. Gelmini, P. Gondolo, and K. Freese, J. Cosmol. Astropart. Phys. **2009** (04), 010.
[Year used as volume number; issue number in ( )]

D. J. Evans, E. G. D. Cohen, and G. P. Morriss, Phys. Rev. Lett. **71**, 2401 (1993); G. Gallavotti and E. G. D. Cohen, J. Stat. Phys. **80**, 931 (1995); J. L. Lebowitz and H. Spohn, J. Stat. Phys. **95**, 333 (1999).
[journal title repeated; *ibid*. no longer used]

5. Books

Italic title of book, followed by Publisher, City, Year in parentheses.
Examples:

P. Kok and B. W. Lovett, *Introduction to Optical Quantum Information Processing* (Cambridge University Press, Cambridge, 2010).

Particle Physics and Cosmology: Dark Matter, edited by M. Srednicki (Elsevier Science, Amsterdam, The Netherlands, 2012).
[editor specified]

V. I. Gavrilenko, in *Tutorials in Complex Photonic Media*, edited by M. A. Noginov, M.W. McCall, G. Dewar, and N. I. Zheludev (SPIE Press, Bellingham, 2009), Chap. 15, pp. 479–524.
[contributor and editors specified]

J. H. Zhu, in *Co-Zr Phase Diagram, ASM Alloy Phase Diagrams Center*, edited by P. Villars, H. Okamoto, and K. Cenzual (ASM International, Materials Park, 2006), http://www1.asminternational.org/AsmEnterprise/APD.
[published book available on website as well]

6. Theses

L. Bretheau, Ph.D. thesis, Ecole Polytechnique, 2012, available online at http://pastel.archives-ouvertes.fr/pastel-00862029.
[degree, university, college, or institution, and year specified. Can include titles]

7. Proceedings

J. Watrous, in *Proceedings of the 36th Annual Symposium on Foundations of Computer Science, 1995* (IEEE, Piscataway, NJ, 1995), pp. 528–537.

G. M. D'Ariano, in *Physics as Quantum Information Processing:Quantum Fields as Quantum Automata. Foundations of Probability and Physics-6*, AIP Conf. Proc. No. 1424 (AIP, Melville, NY, 2012), p. 371.
[AIP Conf. Proc.]

AIP Conf. Proc styled as a journal is also acceptable (each article has a DOI):

M. Alishahiha, The dS/dS correspondence, AIP Conf. Proc. 743, 393 (2004).

R. Bousso, in Proceedings of the Workshop on Black Hole Horizons and Quantum Information, 2013: http://cds.cern.ch/record/1532382.
[unpublished proceedings, title in roman font]

8. E-prints

Note that APS journals do not add arXiv numbers after published journal sources.

R. C. Sterling, H. Rattanasonti, S. Weidt, K. Lake, P. Srinivasan, S. C. Webster, M. Kraft, and W. K. Hensinger, arXiv:1302.3781.
[remove date if given]

R. Agnese *et al*. (CDMS Collaboration), arXiv:1304.4279 [Phys. Rev. Lett. (to be published)].
[e-print submitted to journal, which has recently accepted the paper for publication]

Another version of the same e-print source can be presented if it also contains material under discussion. A description of the different material should be given.

9. Reports

D. Bauer, D. Diamond, J. Li, D. Sandalow, P. Telleen, and B. Wanner, Critical Materials Strategy, U.S. Department of Energy (2011), http://energy.gov/sites/prod/files/DOE_CMS2011_FINAL_Full.pdf.
[report title set roman]

A.P. Hammersley, ESRF Internal Report No. ESRF98- HA01T, 2004 (unpublished).

10. DOI and URLs

DOI links are inserted by the production staff and accompany published journal articles. The DOI number is not displayed as part of the reference for published articles, but is displayed for articles that will not be published later with a page number or electronic identification number.

DOI and URL identifiers also accompany research reports, computer programs, and data sets.

D. van Dyk et al., EOS—A HEP Program for Flavour 424 Observables, 2016, https://eos.github.io/.

11. Supplemental Material

See Supplemental Material at
https://link.aps.org/supplemental/10.1103/PhysRevLett.112.040602 for a derivation of the characteristic polynomial, the critical current, and higher cumulants.
[description of Suppl.Mater. follows link]

12. Astrophysics Source Code Library (ASCL.net)

In astrophysics papers, manuscripts may contain references to ASCL entries.
Sources should be listed as
Author, name of code, version, Astrophysics Source Code Library ascl: 1111.111 (2019).

The version number or specification is helpful but not required. The code name should always be given.

13. Other categories

D. Harlow (private communication).
J. M. Smith (unpublished).
J. M. Smith as discussed in A. Jones, Phys. Rev. B **26**, 1 (1982).
[cited in another paper]
J. M. Smith, computer code CRUX, Bell Laboratories, Murray Hill, NJ, 1972.

14. RMP reference list style

The references in RMP papers are arranged alphabetically by author. As the references are not numbered, citations in text must be identified by authors' names and year of publication. See section on References, footnotes and endnotes in RMP

Because RMP is an archival journal and the reference sections get heavy use, authors are asked to supply names of all coauthors and editors, subtitles of books and conference proceedings, titles of preprints when an article is not yet published, etc. Authors may choose between a standard, short format and a longer format that gives titles of articles and inclusive page numbers (while it is not required, we encourage our authors to provide this information). Whichever style is used, all journal entries in the reference section must follow the same format. Examples of both styles are given below.

a. Journal articles

i. Long format
Zutic, Igor, Jaroslav Fabian, and S. Das Sarma, 2004, "Spintronics: Fundamentals and Applications," Rev. Mod. Phys. 76, 323–410.

ii. Short format
Abe, F., *et al*. (CDF Collaboration), 2000, Phys. Rev. Lett. 84, 5716.

Barrett, R. F., B. A. Robson, and W. Tobocman, 1983, Rev. Mod. Phys. **55**, 155; **56**, 567(E).

Berman, P. R., 2004, Phys. Rev. A **69**, 022101.

Einstein, A., B. Podolsky, and N. Rosen, 1935, Phys. Rev. **47**, 777.

Kobayashi, S., and R. Sari, 2001, Astrophys. J. **551**, 934.

Note that only the first author's name is inverted. Each author's name is followed by a comma, and the name of the last author is preceded by "and."

All coauthors are named for papers with ten or fewer coauthors.
When there are eleven or more, they may be represented by *et al*. in italics.

The journal volume number is in boldface. When a journal has more than one section (e.g., Nucl. Phys. A or B), separate the section letter A, B, etc., from the volume number by a space.

The Barrett *et al*. entry shows an original article followed by an Erratum that appeared in a later issue. For references requiring more than one line, indent the second and subsequent lines one space.

b. Russian journal articles with English journal translations

Maximov, A. V., and V. P. Silin, 1993, Zh. Eksp. Teor. Fiz. **103**, 73 [JETP **76**, 39 (1993)].

List the translation journal after the original Russian journal. Enclose the translation reference in square brackets. Since translations sometimes appear in a later year than the original, give the year of the translation in parentheses at the end. When translation and original appear in different years, the citation in the text should be to the earlier of the two, i.e., the original Russian journal.

c. Books

Braunstein, S., and H.-K. Lo, 2000, Eds., *Scalable Quantum Computers—Paving the Way to Realization* (Wiley, Berlin).

Feynman, R. P., and A. R. Hibbs, 1965, *Quantum Mechanics and Path Integrals* (McGraw-Hill, New York).

Guzzo, L., 2002, in *Modern Cosmology*, edited by S. Bonometto, V. Gorini, and U. Moschella (IOP, Bristol), p. 344.

Mathieu, H. J., 1984, in *Thin Film and Depth Profile Analysis*, edited by H. Oeschsner, Topics in Current Physics No. 37 (Springer, Berlin), p. 39.

When a book is listed under the name(s) of its editor(s), use the abbreviation Ed. (Eds.) after the year.

When the reference is to an article in a collection, use the words "edited by" after the title of the collection, and give the page number of the article at the end. Enclose the names of publishers and cities of publication in parentheses. If the book is published in more than one city, the cities of publication should be separated by slashes. The words "Press," "Verlag," etc., should be omitted from the publisher's name.

d. Conference proceedings

Examples follow.

Lehar, F., 1991, in *Proceedings of the 9th International Symposium on High Energy Spin Physics, Bonn*, edited by K.-H. Althoff and W. Meyer (Springer, Berlin), Vol. 1, p. 113.

Bayanovsky, D., and A. J. de Vega, 2005, in *Magnetic Fields in the Universe: from Laboratory and Stars to Primordial Structures, Angra dos Reis, Brazil, 2004*, AIP Conference Proceedings No. 784, edited by E. M. de Gouveia Dal Pinos, German Lugones, and A. Lazarian (AIP, Melville, NY), p. 148.

Matsuoka, N., K. Hatanaka, T. Saito, T. Itahashi, K. Hosono, A. Shimizu, M. Kondo, F. Ohtani, and O. Cynshi, 1983, in *Proceedings of the 1983 RCNP International Symposium on Light Ion Reaction Mechanism,* edited by H. Ogata, T. Kammuri, and I. Katayama (Research Center for Nuclear Physics, Osaka, Japan), p. 527.

The general treatment of proceedings follows that of books. Spell out the whole title, including subtitle, if any, as it appears on the title page. When the proceedings are part of a series, give the series name and number after the title. Include the name and city of the publisher. If the proceedings are to be published in a special issue of a journal, say so. Do not abbreviate the words "Proceedings" and "International."

If the long style is used for journal article entries giving titles of the articles, it can also be used for proceedings entries, placing the article title after the year and before "in."

e. Theses, preprints, and other references

Examples follow.

Allori, V., 2001, Ph.D. thesis (University of Geneva).

Polchinsky, J., and E. Witten, 1996, "Evidence for Heterotic Type-I String Duality," hep-th/9510169.

Binette, L., 1984, "Photoionisation models for liners: gas distribution and abundances," European Southern Observatory Scientific Preprint No. 350.

Cowley, C. E., 2005, Phys. Rev. A (to be published).

Wagner, Z., 1994, unpublished.

If a preprint exists, but the paper has not yet been accepted for publication, give the e-print arXiv number. For the long form, include the preprint title, in quotation marks. Do not say "submitted to . . . ," "in preparation," or "to appear."

When a paper has been accepted by a journal but not yet published, give the journal name followed by "(to be published)." Frequently such entries can be updated in proof to include volume and page numbers.

If a preprint of the work is not available, the work should be cited as "unpublished" or "private communication," with the year. There is no need to add "unpublished" to a thesis or report reference.

f. Order of reference list

The reference section is arranged alphabetically by author. When several works by the same author are included, these are arranged chronologically. When more than one work by the same author is listed in the same year, they are distinguished by labeling the first, say, 1996a, the second 1996b, etc.

If all papers were by single authors, the above guidelines would be sufficient. However, multiple authorship introduces the need for a few further distinctions. Consider the following list:

Smith, G. F., 1987
Smith, G. F., 1990
Smith, G. F., 1996
Smith, G. F., H. T. Dietrich, and W. K. Lee, 1998a
Smith, G. F., H. T. Dietrich, and W. K. Lee, 1998b
Smith, G. F., W. K. Lee, and H. Sorenson, 1998
Smith, G. F., W. K. Lee, and A. T. Washington, 1989
Smith, G. F., and L. M. Young, 1988

All works by Smith as a single author are listed first, in chronological order. The remaining references are arranged alphabetically by surname of the second author (Dietrich, Lee, Young). When the first two authors are the same, alphabetize according to the surnames of the third authors (e.g., Sorenson, Washington).

Two works by the same group in the same year are distinguished by labeling the first 1984a and the second 1984b. The work by Smith, Lee, and Sorenson should not be labeled 1998c, because the makeup of the group is different from that of 1998a and 1998b.

Occasionally the use of a and b is extended to groups of four or more coauthors that are similar but not identical in makeup. This is done to simplify the task of discriminating among several choices or when the alternative would be a cumbersome citation listing all coauthors in the text. Feel free to consult the editorial office about cases for which you think such a bending of the rules might be warranted.

R. Tables

It is best to treat tabular material consisting of more than approximately four lines as a separate numbered table, complete with a descriptive caption that does not include reference to the text. Tables should be cited in text and numbered consecutively in order of their appearance, using roman numerals I, II, III, IV, etc. Denote footnotes to headings or entries in a table by superscript lowercase roman letters and list at the end of the table. Do not set a footnote to the caption, but incorporate that information in the caption itself.

1. Size and placement

For all journals except PRFluids:
In the PDF publication version, tables, like figures, are placed in corners for one-column width and at top and bottom of the page for medium and two-column widths.

For PRFluids:
In the PDF publication version, tables, like figures, are placed at top and bottom of the page for all widths.

Extra-wide tables with several columns are set as a “turned table” (or landscape form), rotated 90° from standard text direction to accommodate extra columns. Tables are set in the article as close as possible to their citation in text.

Lengthy tables will need to be divided in one of two ways.

(1) A very long, narrow, one-column table can be split and continued in a second column on the same page. It will require a two-column or wide caption, a duplicate set of headings, and wide opening and closing lines.

(2) A very long medium or two-column (wide) table can be continued on the next page or pages. In addition to its first-page caption, headings, etc., it will need a duplicate set of headings, lines, etc., for each additional continued page. It will also require a ``continued'' caption for each additional page of the table:

TABLE I. *(Continued)*

Simple tabular material of less than 4 lines can remain as part of the running text. Such tables are unnumbered and flow into the paragraph structure. A single rule would separate the heading from the body.

Extensive tabular material (and useful information that is not essential to understanding an article's main results) may be deposited as Supplemental Material. For more information, see Supplemental Material Instructions.

2. Captions

A caption is needed for all numbered tables and can consist of an abbreviated sentence (without a beginning article and/or verb), punctuated as a complete sentence. If the caption consists of more than one sentence, treat it as a single paragraph. Lightface roman font is used.

The caption begins with the word TABLE, in capital letters, followed by the appropriate roman numeral and period, and then a small amount of explanatory text. Mathematical terms and relations can be set in the caption, but use in-line format (e.g., broken-down fractions). Symbols, quantities, abbreviations, and initialisms that pertain to the whole table should be defined in the caption. Those already defined in text need not be defined again.

Captions are self-contained and should not carry any footnote indicators.

3. Lines and line spacing

Lines and space are used to separate and define the integral parts of a table. They aid the eye and group information appropriately.

A simple table needs lines or rules in only three locations: two lines together at the beginning and end of the table and a single line separating the headings and columns of entries. A more complicated table, one made up of several parts and having more than one set of headings, will need additional space and lines. Each set of headings will require a line below it and extra space running horizontally above it to separate it from the preceding part of the table.

Use spacing also for grouping. Clear separation of one column and heading from another is created by inserting extra space running vertically between them.
Extra space running horizontally can be used to distinguish broad groups among the entries. Smaller groupings of related entries can be indicated by the use of a single curly brace or a combination of a single curly brace and extra space.

4. Headings

Headings appear above a single rule; entries appear below. Quantities that appear in the headings should be followed by units, given in parentheses. Symbols and abbreviations, if any, should be defined in the caption.

There are two major kinds of headings used in tables:

1. column headings,

2. row headings.

Each type may contain or consist of standard abbreviations, such as Expt., Theor., Calc.. Nonstandard abbreviations should be defined in the caption. Always capitalize the first letter in the first word or abbreviation in all headings and subheadings.

(1) Column headings are separated from the body of the table by a horizontal line. They are usually dropped to the bottom of the heading area. However, units of measure that pertain to each entry in a whole column should be included in parentheses and placed as the last entry in the heading on a line by itself (Illustration 1) or spaced off from the heading on the same line (Illustration 2).

Illustration 1

Branching ratio (%)
1
2
3

Illustration 2

E_x (MeV)	J^π
2720	2^-
4141	2^-

Use centering or straddle rules to group several subheadings under one main heading. Simple single-line column headings should be dropped to the separator rule of the column-heading area. Notice that "Parity" is base-aligned in the example given below.

	$e^- + (e^- e^+)$	$p + (p\mu)$	
Parity	± 1	$+1$	-1
x	x	x	x
x	x	x	x
x	x	x	x
x	x	x	x

(2) Row headings are read from left to right on one line. If there is a heading over the first column, a diagonal line is needed to separate row and column headings.

i \ j	1	2
1	0.3601×10^3	-0.5224×10^1
2	-0.2691×10^4	0.5130×10^2
3	0.7733×10^4	0.1717×10^3

In the body of a table, row headings have similar form. They are read left to right with any units of measure enclosed in parentheses and separated by one space on the same line.

To continue a row heading or indicate a row subheading, indent the second line.

xxx	xxx
1. Counting	
a. Counting statistics in Table IV	0.017%
b. Error in counting estimate	0.02%
c. Error from estimate of ^{240}Pu	0.009%

5. Entry lineup

The manner in which table entries are aligned in their columns will greatly affect the readability of a table. For this reason, use one or a combination of the following types of alignments.

a. Flush left

To be used in a situation in which the entries are not similar and/or of different lengths. All entries are flush left with the column heading centered over the column.

Interpretation
$J = 1$ BE triplet
$J = 0$ BE singlet
BE states from splitoff
Compare B_1 in Fig. 2
Second B_β replica

b. Center

An alternative to lineup (1). Each entry is centered with the column heading centered.

Mode
β^-
Stable
β^+
β^-
Stable
β^-

c. Lineup by digit and/or decimal

To be used in a situation where all or most of the entries are numbers. Align according to digit and/or decimal placement.

Theory	
1	2
9.7	15.6
7.4	7.7
14.9	15.2
24.9	22.9
3.06	3.32
− 0.74	− 0.93

d. Lineup by operator.

To be used in a situation where most entries are similar and have some type of operator (multiplication, plus, minus signs, e.g.) in common.

1
0.4557×10^{1}
-0.2051×10^{1}
-0.650×10^{2}

e. Lineup by unit

To be used when the entries include different units of measurement [see example (a)]. In other cases where all entries include the same unit, the unit designation should be removed from the column entries, enclosed in parentheses, and made part of the column heading [see example (b)]. Lineup will then be by operator, decimal, and/or digit as appropriate.

(a)

Half-life	
41.3 ± 0.1	day
5.37 ± 0.0009	day
11.05 ± 0.02	min

(b)

Half-life (day)
41.3 ± 0.1
5.37 ± 0.009
11.05 ± 0.02

f. Combination of lineups

Whenever possible lineups (3), (4), and (5) should be used in conjunction.

Neutron energy
9840 ± 30 eV
10.34 ± 0.04 keV
10.50 ± 0.02 keV

S. Figures

Figures should be cited in text and are to be numbered consecutively in order of their appearance in text. Use arabic numerals 1, 2, 3, 4, etc.

Figures should be planned for the single-column width (8.6 cm or 3 3/8 in.) of the journal. Use a width of 1.5 or 2 columns for more detailed figures.

For PRFluids: Figures are set in several widths, depending on content. This journal is published in single-column format with a column width of 5.5 in. (13.9 cm)

For all journals:

1. Content

Figures must have a clear background and unbroken lines with as much black-white contrast as possible. When sized for the journal page, the symbol width and lettering height should be at least 2 mm and make the diameter of each data point at least 1 mm. Avoid small open symbols that tend to fill in, small dots and decimal points, and shading or cross-hatching that is not coarse enough to withstand reproduction. Curves should be smooth; curves and lines should have consistent line widths of at least 0.18 mm (0.5 point). The resolution of the drawing software should be set as high as possible (preferably 600 dpi or higher).

2. Captions

Each figure must have a caption that makes the figure intelligible without reference to the text. Define figure symbols and curves either in a legend in the figure itself or in the caption. Label subfigures (a), (b), etc., and include a description of each panel in the caption.

3. Axes

Figures should have properly labeled axes with properly abbreviated units enclosed in parentheses. Use consistent lettering and style as in the body of the text (correct capitalization, unslashed zeros, proper exponential notation, superscripts and subscripts, decimal points instead of commas, etc.). Use the form R (10^3 Ω), not $R \times 10^3$ Ω. Use half spacing or thin spaces inside compound units, not hyphens or periods. Avoid ambiguous usage of the solidus or slash ("/"), e.g., use mb/(MeV sr), not mb/MeV/sr. When possible, integer numbers should be used on the axis scales of figures, e.g., 1, 2, 3, or 0, 5, 10, not 1.58, 3.16, 4.75. Decimal points should be on the line (not above it); do not use commas instead. Use the same number of digits to the right of the decimal point for all numbers on the axis scales. A number must be both before and after the decimal point, e.g., 0.2, not .2.

See also Axis Labels and Scales on Graphs

4. Color figures

Authors may choose either color figures in print and online or color online only with grayscale in print. APS complies with Web Content Accessibility Guidelines, which make online content accessible to the broadest readership possible. Please use accessible color palettes for color figures.

a. Color figures in print and online

If colored figures are desired in the print version of the journal as well as in the online version, clearly indicate which figures are intended to be printed in color when the manuscript is submitted. See the relevant journal's Information for Author page for our pricing and payment policy for printed color figures.

b. Color-online-only figures with grayscale in print

There is no charge for color online only figures. Take care to ensure that captions and text references to the figures are appropriate for both the online color and print grayscale versions and that the figure will be sufficiently clear in both versions. (The same figure file is used for both the print and the online versions.) To achieve this goal, use colors that have clearly distinguished grayscale values. To assist in differentiating colored curves, use different line styles (dashed, solid, etc.) and give a description of the lines in the caption. See Guide to Acceptable use of Color in Color Online Figures for more information

T. Algorithms

1. Captions

Captions should begin with ALGORITHM followed by the appropriate arabic numeral, a period, and then explanatory text.

2. Format

No rules above the ALGORITHM caption. Double rules after the caption and the last line. Use bold font for commands. E.g.,

ALGORITHM 1. Approximate contraction.

Input: tensor network $\mathcal{T}$, ordered contraction tree Y, maximum bond dimension χ, tree gauge distance r, flag `compress.late` //i, j, k, l label tensors, $\mathcal{T}[i]$,… in $\mathcal{T}$.
for i , $j \in Y$ **do**
  if `compress.late` **then**
    for l $\in$ NEIGHBORS($\mathcal{T}$, i) **do**
…

COMPRESS TREE GAUGE (χ, r, $\mathcal{T}$, k, l)
        end if
      end for
    end if
end for
Return: $\mathcal{T}$

---

3. Text citation

Citation in the text should be, e.g., “Algorithm 1”

U. Supplemental Material

Supplemental Material is information that is useful to a subset of readers but is not essential to comprehend the article’s main results. The Physical Review journals archive Supplemental Material, providing permanent access to the information. Supplemental Material includes, but is not limited to, multimedia files, parameters used in or produced by calculations, and computer codes. Information regarding how the research was conducted, such as details of sample preparation, and derivations of equations, can also be included in the Supplemental Material if this information is not crucial to a reader’s understanding of the associated paper. The paper must stand on its own; it must be understandable and convincing without the Supplemental Material.

Supplemental Material is subject to the same copyright agreement as the associated paper. Follow the guidelines in the copyright agreement for the published manuscript when replicating information included in the Supplemental Material.
Do not use Supplemental Material to avoid a length limit; often, a short paper accompanied by a lengthy supplement is not appropriate. Editors use their judgment to decide if a longer manuscript with all material integrated into the main text is required. The editors may seek guidance in this decision from the referees who review the manuscript and Supplemental Material. In a longer format manuscript, it may be best to present additional material as an appendix to the main article, rather than as Supplemental Material.

In general, Supplemental Material should not accompany Comments, Replies, or Errata, but Editors may, in some cases, allow it if supporting data are needed.

All references cited in the Supplemental Material should be listed in the reference section of the main text. For information on how to do this and on how to submit and cite Supplemental Material, see Supplemental Material Instructions.

III. Text: Grammar, Punctuation, Spelling, Hyphenation, and Abbreviations

A. Grammar and punctuation

Good grammar and clear punctuation are essential for successful technical writing. Clear, simple sentence structure best presents scientific ideas and mathematical formulas. For a general guide to good grammar, use, for example, the *McGraw-Hill Education Handbook of English Grammar and Usage*, 3rd ed., by Mark Lester and Larry Beason (McGraw-Hill, New York, NY, 2018).

Specific modification and adaptation of the basic rules are sometimes required by scientific conventions. In addition, the combination of forms including abstract, text, mathematical formulas, figures, tables, and references also creates the need for special structure and style considerations. Below are guidelines to assist you.

1. Text and mathematical sentence structure

(a) Treat the text and mathematical formulas as an entity. Punctuate mathematical expressions as parts of sentences, e.g.:

A slight rearrangement gives

$$D_s = \bar{\xi}_s X^{-1/2} - b,$$

where

$$X = 4t\chi^2(-\ln t)/\pi^2,$$

$$\bar{\xi}_s = \xi_s / t^{1/2},$$

and the reduced transition temperature t is defined to be T_c/T_{cs}.

(b) Avoid beginning a sentence with a symbol or number if the sentence before it has ended with a symbol or number.

2. Use of the comma

(a) Do not surround a symbol with commas or parentheses when it immediately follows the noun that defines it, but do insert the commas or parentheses if another phrase intervenes. E.g.,

As the temperatures approached the melting temperature T_m, all …
As the temperatures approached the melting temperature reported by Green *et al*., T_m, all …

(b) APS journals use the serial (Harvard or Oxford) comma. See the example below, where the second comma is the serial comma.

Symmetry requires that $\omega_1 = \omega_2$, $\omega_3 = \omega_4$, and $\omega_5 = \omega_6$.

(c) Place commas around etc., e.g., i.e., viz., namely, for example, that is, say, in particular, and respectively. Do not use commas around cf. or *et al*.

(d) Nonrestrictive clauses are introduced by "which" and set off by commas.

The $K = 1$ component, which in this case does not influence the band shape, gives rise to …

3. Use of parentheses

(a) When inserting a short parenthetical remark into a sentence, do not punctuate the material within the parentheses.

Recall that the Brown-Green theory (see Sec. II below) must still be tested.

(b) A completely separate parenthetical remark is punctuated as a regular sentence or group of sentences, except that everything including the ending punctuation is enclosed within the bracketing.

… (Recall that the Brown-Green theory is still to be tested.) Again we begin to evaluate …

(c) Square brackets enclose a phrase that already contains parentheses.

Recall that the Brown-Green theory [see Eq. (2)] is still to be …

4. Use of Em dash

(a) Em dashes may be used as a substitute for comma or parentheses, except where adjacent to variables or an equation (so as not to be confused with a minus sign).

"The authors noted that the KdV equation—in the context of inverse scattering theory—can be used to eliminate the number of waves of the train."

"The three relevant types of measurements—in particular, electrical, galvanomagnetic, and thermoelectric transport—are discussed in relation to . . ."

(b) Em dashes are also a good alternative to bold parentheses or braces in a sentence such as

This recombination coefficient—the only coefficient for which the relation $1/4[(a + b)X - 1] = 0$ is satisfied—is large compared with…

(c) Do not substitute em dashes for commas or brackets if it could be mistaken for a minus. For example,

". . .the three remaining Q_m — P, N, and R—in a baryon are in..."

should be changed to

". . .the three remaining Q_m(P, N', and R) in a baryon are in. . ."

5. Use of the colon

(a) Note that an incomplete sentence or phrase introduced by a colon does not begin with a capital letter.

Furthermore, the lake has a natural noise center source: a dam.

(b) A complete sentence introduced by a colon can (but need not) be capitalized.

Finally, the energies of bound surface states are calculated by means of the "effective-Hamiltonian" technique: Let H_{eff} be defined by $E - H_{\text{eff}} = G_0(E^{-1} - V)$.

(c) Do not use a colon after a form of the verb "to be" or between a verb or a preposition and its object.

The momenta of the three α particles in the c.m. system are $\mathbf{p}_1$, $\mathbf{p}_2$, and $\mathbf{p}_3$.

New values were obtained for the quantum cyclotron radius, the Debye shielding radius, and the plasma frequency.

6. Use of the solidus or slash

Except for the term “and/or,” the use of the slash is discouraged between words and abbreviations, as the intent of the solidus is ambiguous. Several possibilities for its meaning exist, among them “and,” “or,” “and/or,” and “plus.” We require that more precise, and therefore more meaningful, conjunctions be used. In some cases, a hyphen or long hyphen (“en” dash) can serve as a replacement; for example, in “Hartree/Fock theory,” the slash should be replaced by a hyphen: “Hartree-Fock theory.”

Some exceptions:
Correspondences
AdS/CFT
AdS/condensed matter
gravity/chaos

The slash can be used between elements or molecules for interface, heterojunction, adlayer, and superlattice notation as well as between symbols, numbers, and units.
See Use of the Solidus between Words, Symbols, and Abbreviations

7. Quotation marks for special usage of a word or phrase

Use double quotes to indicate special usage when the term is first introduced. After that, the term can usually stand on its own. E.g., We designate these as “+” and “–” modes… . Allow a second usage if the term has not been mentioned for a while.

8. Lists

In general, lists are incorporated into a single paragraph with the items identified by (1), (2), etc., and separated by the appropriate punctuation. [Note that parentheses are used on both sides of the identifier.] Sublists would use (a), (b), etc., followed by (i), (ii), etc.

On occasion, items of a list may be set in separate paragraphs. This is generally done only if the items within the list are long and contain complete sentences. Numbers (1), (2), etc., may be added at the beginning of each paragraph to indicate they are a part of the list.

Do not use bulleted lists.

B. Spelling and hyphenation guide

In technical writing the proper spelling and hyphenation of words can be a controversial point of style. In general, for nontechnical words refer to Webster's New International Dictionary if a question of correct form arises. Use the first spelling if there is more than one version provided. A list of general spelling and hyphenation rules follows.

(1) American, not British, spellings are used except in proper names.

(2) Use single, not double, consonants in forming endings (e.g., labeled and not labelled). However, if the accent is on the last syllable, then double the consonant, e.g., controlled.

(3) Contractions should not be used, for example, let's, don't, shouldn't. Please use expanded forms instead: let us, do not, should not.

(4) To form the plural of decades, numbers, and abbreviations add s (1980s, 10s, BECs); for symbols add 's (*A*'s, δ's).

(5) To form the possessive of names, add 's (apostrophe s), regardless of the number of syllables or final letter (Green's, Jones's, de Gennes's).

(6) Most adjectives and nouns formed from proper names such as Gaussian and Ohmic are capitalized. The names of units in expanded form begin with a lowercase letter, e.g., tesla, angstrom, and volt. Names of most particles created from proper names start with lowercase letters as well (boson and fermion, but not Pomeron), as do minerals (scheelite).

(7) Use small capitals to identify computer program names (VASP), designation of ionization states in atomic spectroscopy (He II), and the names of logical operations, gates, and related terms (AND, NOT, CNOT, SWAP, OFF, ON).

(8) We prefer that superscript and subscript numbers be used with element abbreviations for the following categories:

- Atomic mass ^{12}C, e.g.
- Atomic number $_{2}$He, e.g.

(9) Names of specific spacecraft and satellites should be set italic: *Planck* satellite, *Keck Array*, *LAGEOS*, *Phoenix* Mars lander

(10) Prefixes and suffixes with words are usually closed up (nonradioactive, nonspacelike, wormlike, multichannel, postmerger). Hyphens are added in the following cases:

- when a double letter is produced (e.g., semi-infinite, multi-ion, non-negligible, sub-barrier) but there are exceptions (e.g., superresolution, preexisting, deexcitation, subband).
- when a prefix or suffix is added to a proper noun (non-Ohmic or Einstein-like),
- when a prefix or suffix applies to two or more words (non-time-dependent, pseudo-Fermi-function, pseudo-wave-function, free-electron-like),
- if closing up could change the meaning of the word (un-ionized, re-form, re-solve).
- "self" words and "free" words should be hyphenated (self-consistent, divergence-free).

(11) Italic chemical prefixes should be hyphenated (*cis*-dimethylethylene, *ortho*-terphenyl); roman chemical prefixes should be closed up with the name of the element or compound (orthohydrogen, poly*A*).

(12) Numbers above 10 should be hyphenated, as in 11-fold (but note *twofold*). Use hyphens with italic *n* as in *n*th, (*n* – 1)th [or (*n* – 1)st], *n*-fold, *n*-tuple.

(14) Some "half" words would always require hyphens, regardless of usage or placement. What follows are noun forms with hyphens:

half-distance
half-width
half-life
half-integer
half-length
half-line
half-metal (half-metallic)
half-period
half-space

However, note the lack of hyphens in the nouns in

half angle
half cycle
half filled
half maximum
half plane
half space
half wave

(15) To prevent ambiguity and make reading easier, hyphens may be inserted in word pairs that function as adjectives when they occur before a noun, as in "x-ray diffraction,"

“4-mm-long gas cell,” and “*R*-matrix theory. However, hyphens should not be used in word pairs when they are not used as adjectives before nouns, as in “emission by x rays,” “was 4 mm in length,” and “the *R* matrix is tested.” Hyphenation should be consistent throughout.

Editorial policy varies on this subject from journal to journal. Check a recent issue of the journal in which you are publishing. Our copyeditors will apply journal style.

(16) Do not hyphenate compound modifiers containing an adverb ending in -ly (highly complex behavior) except in phrases of three or more words where the entire phrase should be grouped together (three-dimensionally-aligned molecules).

(17) Strings of modifiers can be sorted with a combination of short and long hyphens (two-particle–two-hole configuration, ferromagnet–dielectric-material stack, resistance–magnetic-field plot).

(18) A hyphen also can be used as a sorting agent in predicate adjectives of three or more words (... is face-centered-cubic).

(19) Use a hyphen in written-out numbers of two words or more (twenty-five).

(20) Use hyphens in the names of materials such as β-brass, (o)-H_2.

(21) Use hyphens in phrases with prepositions as an aid to understanding: out-diffusion, in-diffusion, spill-out, up-conversion, down-conversion.

(22) Use en dashes between compound surnames (“de Haas–van Alphen”).

(23) Do not hyphenate compound nouns when used adjectivally. Use an en-dash between the compound noun and the adjective: Monte Carlo–based

C. Abbreviation guidelines

When creating or using abbreviations, please keep the following recommendations in mind.

(1) An abbreviation of a single word should be a shortened form of that word, especially in indices or subscripts. Lowercase roman letters should be used without punctuation (obs for observed, av for average, const for constant). For table headings, such abbreviations should be punctuated with a period and set with an initial capital letter (Obs., Calc., Theor., Expt.). Error abbreviations set online can be punctuated or not and set in parentheses, e.g., 2.62 (syst.) 5.21 (stat.) or 2.62 (syst) 5.21 (stat).

(2) An initialism is an abbreviation of a phrase that includes the initial letters of the words of the phrase, presented in capital roman letters. An acronym also consists of the initial letters of words but can be (and is) pronounced as a single word. Most abbreviations in our articles are initialisms or acronyms. Examples are distorted-wave Born approximation (DWBA), Bardeen-Cooper-Schrieffer (BCS) theory, density of states (DOS), and superconducting quantum interference device (SQUID).

New terminology should convey to the reader an accurate impression of its meaning. Ensure it is not frivolous or difficult to pronounce. When new abbreviations of phrases are created, use capital letters for each word, even prepositions [e.g., equation of state (EOS)]. A few historical abbreviations are exceptions to this guideline and use lowercase letters, such as bcc for body-centered-cubic, ac for alternating current, and rf for radio frequency. Note that abbreviations should be the same case in text and in subscripts/superscripts.

Use one definition of the initialism or acronym throughout the paper. For example, if you define SEM as "scanning electron microscopy" (which is a technique), the abbreviation should refer only to the technique throughout the paper. This sentence would be incorrect if included in the same paper: We used an SEM in our experiments. Although the first letters of each word are the same for technique and instrument, the initialism or acronym should be consistent with the expansion of the phrase being abbreviated.

Avoid excessive use of acronyms, as too much specialized jargon can inhibit communication.

(3) When you are using an abbreviation of a proper name as a superscript or subscript, retain the initial capital letter (E_{Coul} or E_C for Coulomb energy; E_R for Rydberg energy; use "AS" in subscripts to denote "anti-Stokes," not "as").

(4) Do not use multiletter abbreviations as mathematical variables. Use the conventional symbol instead, e.g., E_K or E_{kin} , not KE, for kinetic energy. See also Multiletter Symbols .

(5) Abbreviations used more than once should be defined the first time they are introduced in the abstract and in the text, i.e., . . . to study the effect of dissipation-assisted operator evolution (DAOE) on . . . Thereafter it is acceptable but not required to use the abbreviation without definition.

(6) See Appendix for list of Abbreviations and Acronyms

Also note:

- When an abbreviation follows an indefinite article, the choice of "a" or "an" is determined by the way the abbreviation would be read aloud: an LED (el ee dee);

a He (helium) atom; a HWHM (half width at half maximum) of…; an HVAC (aitch-vac) system.

- Form the plural of uppercase acronyms by adding "s": PMTs (not 's). An apostrophe is necessary for lowercase acronyms: rms's.
- Keep the distinction between singular and plural acronyms. For example, if PMT is defined as a "photomultiplier tube," then use PMTs when discussing more than one photomultiplier tube.
- When defining an acronym for the first time when used in a hyphenated phrase, set the hyphen after the acronym: CD-Bonn becomes charge-dependent (CD)-Bonn.
- In general, PR discourages the use of mixed cases (lowercase and uppercase) within an acronym, but there are exceptions. E.g., the letters that are part of a proper noun (e.g., dHvA for de Haas–van Alphen).

See also section on Abbreviations in Subscripts and Superscripts

D. Units of measure

The use of metric units [of the Système International d'Unités (SI)] is preferred. This system is based on the meter, second, kilogram, ampere, kelvin, mole, and candela. [See the International System of Units (SI), NIST Spec. Publ. 330, 2019 Edition and Guide for the Use of the International system of Units (SI), NIST Spec. Publ. 811, 2008 Edition.]

(1) Decimal multiples or submultiples of units are indicated by the use of prefixes. The combination of prefix and unit symbol is treated as a single symbol. Such a combination can be raised to a power, e.g., cm^2. As an example, compound units are written 1 g cm^2 or g cm^2 s^{-2}, with a thin space between unit parts. Note that multiple slashes as in 6 J/cm^3/s is ambiguous and thus should be modified. Set as 6 J cm^{-3} s^{-1} or 6 J/(cm^3 s).

d deci (= 10^{-1})	n nano (= 10^{-9})	da deka (=10)	G giga (= 10^9)
c centi (= 10^{-2})	p pico (=10^{-12})	h hecto (= 10^2)	T tera (= 10^{12})
m milli (= 10^{-3})	f femto (= 10^{-15})	k kilo (= 10^3)	P peta (= 10^{15})
μ micro (= 10^{-6})	a atto (= 10^{-18})	M mega (= 10^6)	E exa (= 10^{18})

(2) In general, the abbreviations for units of measure have one form for both singular and plural use, are unpunctuated, are set in roman font, and appear a full space away from the preceding number: 1 cm, 2.7 cm.

(3) Most symbols for units are printed in lowercase roman type without periods. Units derived from proper names, however, are written with initial capital letters, i.e., C for coulomb, Wb for weber.

(4) Numbers and units should be presented as follows. The abbreviation should be used after a number given in numeral form: 1 cm (not 1 centimeter or one cm). The unit should be spelled out in cases such as "a few centimeters."

(5) Units composed of symbols or letters denoting quantities are set closed up with the preceding number: 2.4%, 90°, 30", $20\mu_{\mathrm{B}}$, $50\{a\}$, $50M_{\odot}$.

(6) The Greek letter mu (μ) for the "micro" prefix is set in roman font (for example, μs, μm, μW, μl, μA, μF, μeV). As a quantity or variable, μ is set italic.

(7)

Common Abbreviations and Misuses	
Use	**Do Not Use**
μm	μ
nm	mμ
fm	F (F is for farad)
g	gm
A	amp
K	°K
sr	Sr, ster, str
u	amu
cm^3	cc
deg	DEG, DEG., deg.
keV	KEV, KeV
MeV	Mev, MEV
MeV/nucleon	MeV/u, MeV/amu, MeV/*A*
μ_N	n.m.
c.m. (=center of mass)	CM
arb. units	a.u. (for atomic units)

See Appendix for a list of standard Units of Measure.

E. Numbers

- Numbers of 4 digits (up to 9999) are closed up and unpunctuated: 1200, 1697, 9999.
- Use words for numbers up through ten (one equation, nine tests; first, second, third . . ., ninth; tenfold) and numerals for numbers 11 and above (11 equations, 20 tests; 21st, 22nd, 23rd, . . ., 30th; 11-fold). There are exceptions, some of which are listed below.

  (i) Spell out numbers above ten if they begin a sentence: "Twenty-five values were obtained. . .." But never spell out a number, regardless of position, if it takes three or more words to do so: "125 values were obtained. . ." (and, if it can be done simply, recast the sentence so that it begins with a word: "We obtained 125 values for. . .").

  (ii) Prevent the collision of two numbers written in numerals ("40 12 cm tubes") by spelling out the first of the numbers (forty 12 cm tubes") ["but 125 12 cm tubes"; see exception (i) above].

  (iii) Fractions may be written in words (one seventh, one half) or in numerals [slashed (1/7)]—but always, for example, 1/48 rather than "1/148th," which is redundant ("one-forty-eighth-th").

  (iv) Spell out "hundred" and "thousand" only in designations of unspecified amounts ("several hundred collisions," but "200 collisions").

  (v) The words "billion" and "trillion" mean different things in different countries. Change "billion" (1,000,000,000) to " $\times 10^9$," "trillion" (1,000,000,000,000) to " $\times 10^{12}$," and, for consistency, "million" (1,000,000) " $\times 10^6$," Example: three billion (3,000,000,000) cats becomes 3×10^9 cats. However, "million" and "billion" are allowed in nontechnical usage, i.e., "six million years from now" is retained.

  (vi) For consistency, write all the numbers as numerals in lists containing numbers less than and greater than ten: "Groups of 8, 52, and 256 particles . . . ."
- Numbers used as nouns are always numerals:
  - factor of 4
  - sample 2, counter 4
  - ratio of 3:5
  - values of 3 and 7
  - 2 bytes, 8 bits
  - 1–10 (a range of numbers)
  - 2 orders of magnitude
  - 4 times
  - 3 meV (a number followed by any unit of measure)
  - 1 degree of freedom
  - smaller than 1
  - larger than 1
  - power of 6

- 1 standard deviation
- close to 1

"Unity" and "zero" are sometimes exceptions: "value of zero." Observe the excellent clarity of "Its eigenvalues are such that one is much greater, and the other much less, than 1."

IV. Mathematical material

Mathematical or symbolic material can be difficult to present in a clear, concise manner. By nature it is often complex and this makes specialized treatment a necessity. Conventionally accepted notation and standardized forms are an aid both to the author and reader. It is with this in mind that the following instructions and guidelines have been presented.

See also General Notation and Terminology

A. Characters available in APS publications

1. Alphabets

There are two alphabets used conventionally: Greek and Latin (upper- and lowercase letters of each) in lightface and boldface. The Latin alphabet is available in several letter type fonts: roman (upright), italic (slanted), script (cursive), German (Fraktur), and sans serif (unadorned).

Each alphabet and font has specialized uses. The two main Latin fonts, roman and italic, are used to create a distinction between words and mathematical symbols. Latin letters as mathematical symbols are conventionally printed in the italic font to distinguish them from the text material, which is printed in the roman font. Below are listed specific uses for both alphabets and the fonts.

a. Greek alphabet

Letters of the Greek alphabet are used to represent the following: some variables and constants, symbols for some particles, some operators, and some units of measure. Note here that the Greek letter, not the word, is commonly used in most situations.

b. Latin alphabet

(i) Roman font

English words and abbreviations of words
Elements in the periodic table and chemical symbols and compounds
Most multiletter abbreviations (both on the line and in subscripts and superscripts
Units of measure
Derivatives and differentials: d, d*x*, d*t* (or *d*, *dx*, *dt)*
Imaginary unit i (or *i*)
exponential e (or *e*) (takes a superscript)
Bold three-vector notation (e.g., **k**)
Most multiletter operators, functions, and dimensionless numbers (e.g., exp, ln, log, sin, Re, Im, sgn, Tr, Re for Reynolds number, Ca for capillary number) See also Fluid Dynamics Notation
Principal value P
Modes (e.g., TE, LO)
Data-run identification labels (e.g., run IIa, 3b)
Symmetry groups and algebras [e.g., SU(3), O(*n*), su, SL(*x*)] See also Group Symmetry and Algebra
Figure part labels [e.g., (a), (b), etc.]
Letters in equation numbers [e.g., (1a), (1b)], figures, tables, and section headings,
Letters in enumerative lists [e.g., (i), (ii), (a), (b)]
cf., viz., i.e., e.g., etc., vice versa

(ii) Italic font

In text, Italic font is used for non-English words (*ab initio*, *a priori*, *et al.*, *ibid*, *in situ*) or for words or phrases that indicate emphasis. Setting whole sentences in italics is discouraged, as this practice may distract the reader and detract from intention.

Italic font is used to represent the names of spacecraft:
Fermi, Planck satellite

Scientific presentation:
Single-letter variables, quantities, constants, operators
Symbols for particles (e.g., *e,n,p*)
Axes and planes (e.g., *a,b,c*)
Channels (e.g., *s,t,u*)
Types of semiconductors (e.g., *n,p*)
Bands (e.g., *A,B,C*)
Geometric points, angles, and lines (e.g., *ABC, abc*)
Some chemical prefixes
Symmetry designations (e.g., D_{4n}, O_h, 6/*mn*)
Color centers (e.g., *F*)

Quantum-state symbols in spectroscopy (*s,S,p,P,d,D,f,F*)
s wave, *p* wave
Brillouin zone points (e.g., *K,L,M*)
In an alloy notation: the major constituent is italicized, the other chemical symbol is roman (as usual), e.g., *Cu*Mn.
Derivatives and differentials: *d*, *dx*, *dt* (or d, d*x*, d*t*)
Imaginary unit *i* (or i)
exponential *e* (or e) (takes a superscript)
Euler's number *e* (base of the natural logarithm)
Lines, such as D_1, D_2 optical transitions
NN to represent nucleon-nucleon
C-P, *C-P-T* to represent charge-parity, charge-parity-time
I-V for current-voltage characteristics (also *I-R* for current-resistance characteristics)
P-V-T (pressure-voltage-temperature) relationship
Pmmm to represent a space group
rare earth *R* and metal *M* are italic in chemical compounds
order of (*O*, *o*)

(iii) Script, Matchal

Some quantities ($\mathscr{E}$ or $\mathscr{E}$) and operators ($\mathscr{H}$ or $\mathscr{H}$ for Hamiltonian); constants ($\mathscr{R}$ or $\mathscr{R}$); matrix elements ($\mathscr{M}$ or $\mathscr{M}$); some quarks ($\mathscr{P}$ or $\mathscr{P}$, $\mathscr{N}$ or $\mathscr{N}$); parity-time ($\mathscr{PT}$ or $\mathscr{PT}$).

(iv) Fraktur or German font

Some quantities and operators.
Note: use roman Re and Im for "real part" and "imaginary part," not German R and German I, i.e., $\mathfrak{R}$ and $\mathfrak{I}$ (\mathfrak).

(v) Sans serif font

A few quantities (S,T in tensor notation), shapes (e.g., L shaped), and a few operators.

(vi) Boldface font

Reserved for three-vectors, and some matrices.
Dyadics are represented by roman font and appropriate diacritical mark, e.g.,
$\overleftrightarrow{a}$

See also Vectors, Matrices, etc.

(viii) Other fonts

Reduced-size terms are used for computer programs, codes, packages and languages that are in all caps, e.g., GAUSSIAN, and logical operators (AND, XOR, OR, NAND, NOR).

Typewriter font is used for computer program lines and subroutines.

B. Abbreviations in mathematical terms

Usage of multiletter abbreviations that designate mathematical functions has been standardized. The roman font is to be used, e.g., cos and tan. See Appendix for list of common "roman" functions.

1. Abbreviations in subscripts and superscripts

a. Single-letter abbreviations

It is Physical Review convention to set most single-letter abbreviations in italic font, i.e., E_C where C stands for Coulomb, k_B where B denotes Boltzmann, r_d where d denotes disk. Single-letter abbreviations in subscripts and superscripts can be set in either italic or roman font, e.g., k_B or k_{B} where B denotes Boltzmann, r_d or r_{d} where d denotes disk. Please be consistent in the font choice for each letter. Note that single-letter abbreviations should be roman if that is the accepted scientific style. E.g., single-letter element abbreviations (e.g., O, H); units of measure (e.g., s for seconds, h for hours).

b. Multiletter abbreviations

Multiletter abbreviations are conventionally set in roman font whether they represent one or more words, i.e., E_{lab} , where lab stands for laboratory (truncated word, lowercase) and E_{HF} , where HF stands for Hartree-Fock (acronym), a compound term of two proper names.

Always capitalize abbreviations that represent proper names.

C. Mathematical expressions

1. Displayed equations

Display the following: (1) equations of importance, (2) all equations that are numbered, (3) those that are too long to fit easily in text (over ~25 characters), or (4) those that are complicated (full-size fractions, matrices, or matrixlike expressions). Consider, also, displaying math that contains multilevel indices, integral, summation, and product signs, with multilevel or complex limits, or any other situation in a formula that creates the need for extra vertical spacing in a text line.

2. Punctuation

Even though displayed math expressions are separated by space from the running text, they are still part of text and need to be punctuated accordingly. As the equations are often part of a sentence, punctuation is to be inserted.

Example:

The final result is

$$H_{ij} = \left(\frac{\Omega}{\Delta}\right)^2 \frac{|J|^2}{E_g + \frac{1}{2}(W_c + W_v)} e^{\lambda \mathbf{K}\cdot\mathbf{R}_{ij}}, \qquad (11)$$

where

$$\mathbf{K} = \frac{1}{a}(\hat{\mathbf{i}} + \hat{\mathbf{j}} + \hat{\mathbf{k}}) \qquad (12)$$

and

$$\lambda = \ln[W_l W_v/(12E_g)^2]. \qquad (13)$$

3. Numbering

See earlier section on Equation numbering

D. Bracketing

1. Grouping Sequence

For the purpose of grouping, the sequence of bracketing preferred for APS publications is { [( )] }, working outwards in sets ( ), [ ], and { } . If you have used these three sets and need additional bracketing, begin the sequence again in the same order but in bold font: **{[(** { [( )] } **)] }**. Note that the same type of brackets but of different sizes are not considered nested.

For grouping situations that contain fractions and need larger-sized bracketing, it is preferable to start again at the beginning of the sequence around the built-up material:

$$\left[\left(\frac{(a-2)^{1/2}}{a^2}\right)\left(\frac{(x+2)^{1/2}}{b}\right)\right] = 0$$

See also Bracketing in Mathematical Expressions

2. Specialized bracket notation and ordering in combination cases

Bracketing (following the standard sequence and special) is used to create specific notation that defines what it encloses. A list of specialized notation is included below.

Plane or set of parallel planes	(111)
Direction	[111]
Class (group) of symmetry equivalent directions	⟨111⟩
Class (group) of symmetry equivalent planes	{111}
Point designated by coordinates	(*x*,*y*,*z*)
Lattice position in a unit cell (*not* bracketed; included for your information)	$\frac{1}{2}\frac{1}{2}\frac{1}{2}$
Vector written in components	(H_z,H_y,H_z)

Commutator	$[f,g]$
Iterated commutations	$[H_0,[H_0,H_1]]$
	or $\mathbf{[}H_0,[H_0,H_1]\mathbf{]}$
Functions When the argument of a function contains parentheses, it is preferred to enclose it in bold parentheses instead of square brackets	$\Gamma\mathbf{(}\frac{1}{2}(x+y)\mathbf{)}$
Functionals Use square brackets to enclose arguments for functionals that contain parentheses	$F[\varrho(r)]$
Anticommutators	$\{f,g\}$
Sets	$\{x\}$
Coefficients of fractional parentage	$\{\|\sigma_i\|\}$
Absolute values	$\|a\|$
Determinants	$\|x\|$
Notation used to indicate at what value of the argument some quantity is to be taken	$\|_{s\to\infty}$
Matrices or norms	$\|\|f\|\|$
Averages	$\langle\ \rangle$, $\langle\ \rangle_{\mathrm{av}}$
Dirac bra-ket notation	$\langle\ \|\ \|\ \rangle$ and $(\ \|\ \|\ )$,

When used in an equation along with standard sequence bracketing, this special kind of bracketing should not alter the regular sequence of bracketing. The special notation $\langle\ \rangle$ in the following equation does not interfere with the sequence of the equation bracketing:

$$\hbar[\langle E\ -\ (a\ +\ 1)\rangle]^{-1} = 0.$$

Ordered bracketing is also used to create specialized notation, e.g., $[L_2,L_3]$ in the equation below:

$$\tfrac{1}{3}\{-\ i(L_1\,[L_2, L_3]\ +\ T)\}\ =\ 0.$$

When there is a mixture of bracketing that orders and defines, the order sequence starts at the beginning with parentheses, skips the specialized notation (in this case, square brackets) and goes on to the next ordered bracket set (curly braces). There are situations where special bracketing will occur in pairs, i.e.,

$$\left|\left|r^2 + r^2\right|\right|^{1/2}, \quad \langle\langle r^1 + r^2\rangle\rangle_{\text{av}}, \quad (r||f(r)).$$

The outside bracket set should be bolded.

See also Crystallographic Notation

E. Additional style guidelines

1. Placement of limits

In displayed mathematical terms, limits are treated in the following manner:

$$\sum_{\substack{i,j,k \\ i<j<k}} \quad \sum_{n=1}^{\infty} \quad \sum_{l}' \quad \prod_{n>1} \quad \int_{-\infty}^{+\infty} \quad \lim_{\alpha \to 0}$$

Stacking of limits, seen in the first example, is possible, as is centering. In text, however, space limitations require that limits be treated as subscripts and superscripts. The second example above should be set $\Sigma_{n=1}^{\infty}$ in text. The stacking in the first example would mean that any math containing that summation should be displayed or be rewritten.

2. Fractions

Fractions can be “built up” with a fraction bar $\frac{a+b}{c}$,

“slashed” with a solidus, $(a+b)/c$, or

written with a negative exponent, $(a+b)c^{-1}$.

In standard articles, in text all fractions must be either slashed, cased, or written with a negative exponent. In displayed math all three forms are allowed. In TeX, sized fractions are acceptable in text and display.

Apply the following guidelines:
(a) Use built-up fractions in matrix notation (instead of the slashed configuration):

$$M_1 = -\begin{pmatrix} \frac{\partial^2}{\partial x^2} & 2\theta'_0 \frac{\partial}{\partial x} \\ \theta_0 \frac{\partial}{\partial x} & \theta_0^2 \frac{\partial^2}{\partial x^2} \end{pmatrix}.$$

(b) Use built-up fractions (instead of the slashed configuration) if there are three or more simple fractions in a formula:

$$H_A(w) = \left[\frac{1}{2}\left(\frac{Q}{\pi\omega^2}\right)^2 + \frac{c_e^2}{4d}\right]\pi\omega^2 d.$$

(c) Using slashed fractions in subscripts, superscripts, and limits is preferred:

$$\mathcal{N}^{-1/2}.$$

(d) Use slashed or sized fractions in the numerators and denominators of built-up fractions except where excessive bracketing would obscure your meaning or slashing would interfere with continuance of notation:

$$\varphi + \frac{(\beta/6)\varphi}{\gamma+[\beta(\beta-1)/12]\varphi^2} = 0.$$

(e) When slashing fractions, respect the following conventions. In mathematical formulas this is the accepted order of operations:

1. raising to a power,
2. multiplication,
3. division,
4. addition and subtraction.

According to the same conventions, parentheses indicate that the operations within them are to be performed before what they contain is operated upon. Insert parentheses in ambiguous situations. For example, do not write *a*/*b*/*c*; write in an unambiguous form, such as

$$(a/b)/c$$

or

$$a/(b/c),$$

as appropriate.

3. Multiplication signs

The primary use of the multiplication sign is to indicate a vector product of three-vectors $\boldsymbol{\kappa} \times \mathbf{A}$. Do *not* use it to express a simple product except
(1) when breaking a product from one line to another (described in equation breaking, Sec. IV C) or
(2) for other cases such as indicating dimensions ($3 \times 3 \times 3$ cm^3), magnification ($3\times$), symbols in figures ($\times$'s), or numbers expressed in scientific notation (5.3×10^2 MeV).
The center dot also should not be used to mean a simple product. Use the dot to represent inner products of vectors and dyadics ($\boldsymbol{\kappa} \cdot \mathbf{A}$).

See also Multiplication Signs

4. Crystallographic notation

See Crystallographic Notation

5. Atomic and molecular notation

Elements are roman:
H, Na, Cl, P, etc.

Superscripts to elements indicate charge states:
Ca^{2+} (not Ca^{++})
Ca^{2+*} for an excited ion

For more examples and information see Atomic and Molecular Notation

4. Other mathematical symbols

The use of the following standard symbols is strongly recommended.

$\approx$	approximately equal ($\simeq$ and $\cong$ are also acceptable)
$\propto$	proportional to
$\rightarrow$	tends to
$\sim$	asymptotically equal to
$O(\ )$	of the order
A^*	complex conjugate of A
$A^\dagger$	Hermitian conjugate of matrix A
$\tilde{A}$, A^T	transpose of matrix A
$\hat{\mathbf{k}}$	unit vector $\mathbf{k}/k$

See also Preferred Notations for Limiting Behavior and for Approximations

Appendixes

Abbreviations and Acronyms

* = No need to define

1D	one dimensional
2DEG	two-dimensional electron gas
AB	Aharonov-Bohm
ABC	Abashian-Booth-Crowe (particle, anomaly)
ABFST	Amati-Bertocchi-Fubini-Stanghellini-Tonin
ABMR	atomic-beam magnetic resonance
*ac	alternating current
a.c.	accommodation coefficient
ACR	auxiliary control register
*A.D.	anno Domini [now CE (Common Era)]
ADC	analog-to-digital converter
ADK	Ammosov-Delone-Krainov
ADP	ammonium dihydrogen phosphate
AdS	anti–de Sitter
*AdS/CFT	anti–de Sitter/conformal field theory (PRA/E: define. Use AdS-CFT, not AdS/CFT. AdS+CFT also acceptable if given by author)
a.e.	almost every (spell out in text, leave in math)
AEM	analytical electron microscopy
AES	Auger-electron spectroscopy
AF	antiferromagnetic (AFM also used)
*af	audio-frequency
AFC	automatic frequency control (circuits) (not “controlled”)
*AFM	atomic force microscope, atomic force microscopy
AFMR	antiferromagnetic resonance
AG	Abrikosov-Gor'kov

AGS	alternating-gradient synchrotron
Ai	Airy function (also Bi, Ci) do not define in equations, in text define as “where Ai is the Airy function”
*alt	altitude
*(am)	ammoniated [follows compound: NaCl(am)]
*a.m.	ante meridiem
ANNI	axial nearest-neighbor Ising
ANNNI	axial next-nearest-neighbor Ising (model)
ANOVA	analysis of variance
AO	atomic orbital
AOM	acousto-optic modulator
APCVD	atmospheric pressure chemical vapor deposition
APD	avalanche photodiode
*approx	approximate (in subscript)
APW	augmented plane wave
arb. units	arbitrary units (not a.u., which stands for atomic units)
AR	antireflection
ARL	Applied Research Laboratories
ARPEFS	angle-resolved photoemission fine-structure spectroscopy
ARPES	angle-resolved photoelectron spectroscopy
ARUPS	angle-resolved ultraviolet photoemission spectroscopy
ARXPS	angle-resolved x-ray photoemission spectroscopy
ASE	anomalous skin effect
ATI	above-threshold ionization
ATM	atomic tunneling microscopy
ATR	attenuated total reflection
a.u.	atomic units
aug-cc-pVDZ	augmented correlation-consistent polarized valence double zeta [also TZ, QZ, 5Z instead of DZ; for triple zeta, quadruple zeta, five zeta]
*av	average (in subscript)
*AWG	American Wire Gauge (“No. 40 AWG Cu wire”)
B3LYP	Becke three-parameter Lee-Yang-Parr (functional)
B88	Becke 1988 (functional)
B92	Bennett 1992 (protocol)
BA	Bohm-Aharonov (effect); change to Aharonov-Bohm
BB84	Bennett-Brassard 1984 (protocol)
BBGKY	Bogoliubov-Born-Green-Kirkwood-Yvon
BBO	beta barium borate (always follow by “crystal”)
*B.C.	before Christ [now BCE (before Common Era)]
B.C., BC	bubble chamber or boundary condition
*bcc	body-centered-cubic
BCD	binary-coded decimal (computer language mode, spell out)

*BCS	Bardeen-Cooper-Schrieffer (do not define, but spell out in title)
bct	body-centered-tetragonal
BdG	Bogoliubov–de Gennes (equation, formalism, etc.)
BDH	British Drug Houses
BDJ	Bijl-Dingle-Jastrow
BEC	Bose-Einstein condensate (or . . . condensation; PRA/E: define at first occurrence and spell out in title, but not in composite "BEC-BCS" or if otherwise cumbersome)
BEC-BCS	Bose-Einstein condensate (BEC) to Bardeen-Cooper-Schrieffer (BCS) (OK not to spell out in title)
BET	Brunauer-Emmett-Teller (isotherm;method of area measurement)
BI	background integral
BIS	bremsstrahlung isochromat spectroscopy
BJL	Bjork en-Johnson-Low (limit) (in field theory)
BLYP	Becke–Lee-Yang-Parr (functional)
BM	basilar membrane
BMpc	beam monochromator (preset count)
*BNC	type of connector
BO	Born-Oppenheimer
*bp	boiling point
B.R.,BR	branching ratio
BRT	Bardeen-Rickayzen-Tewordt (theory of superconductivity)
BS	(i) Bethe Salpeter (ii) Biot-Savart (iii) Bogoliubov-Sadovnikov (iv) Bohr-Sommerfeld (v) Blankenbecler-Sugar (vi) band structure
BUU	Boltzmann-Uehling-Uhlenback
BZ	Brillouin zone
*ca.	*circa* ("around," "approximately") [not properly a part of notation ("at ca. 48 K")]
CAD	computer-aided design
C-AFM	conductive atomic force microscopy
CAI	computer-assisted instruction
*calc	calculated (in subscript) (use calc. as column heading)
CAR	canonical anticommutation relation
CARS	coherent anti-Stokes Raman spectroscopy

CAS	complete active space
CAT	(i) controlled atmosphere technique (ii) computerized axial tomography (CAT scan) (do not define)
CBE	chemical beam epitaxy
CBED	convergent beam electron diffraction
c.c.	complex conjugate (define, but not if used in an equation)
CCC	convergent close-coupling (theory or method)
CCD	charged-coupled device (PRA/E: do not define)
CCBA	coupled-channel Born approximation
CCR	(i) constant charge ratio (in nuclear-fission theory) (ii) canonical commutation relation
CCSD	coupled-cluster (theory) with single and double excitations
CCSD (T)	coupled-cluster (theory) with single, double, and partially triple excitations
ccw, CCW	counterclockwise (spell out]
CDC	Control Data Corp. (define, but not if part of a computer designation: CDC 6600]
CDD	Castillejo-Dalitz-Dyson
CDW	(i) charge-density wave; (ii) continuum distorted wave (often in connection with EIS: CDW-EIS]
CE	charge exchange; Common Era
CEP	conduction-electron polarization; carrier envelope phase (in most cases for PRA/E]
CESR	conduction-electron spin resonance
*cf.	*confer* (“compare”) [Use “Cf.” at beginning of sentence (“Compare” looks better, especially in text). Does not mean “see.”]
CFL	Courant-Friedrichs-Lewy
cfp,CFP	(i) coefficient of fractional parentage (in nuclear physics); (ii) configuration fraction percentage (in chemistry)
CFT	conformal field theory
c.g.	center of gravity
CG	Clebsch-Gordan (coefficients}
CGLN	Chew-Goldberger-Low-Nambu
*cgs	centimeter-gram-second (system)
*Chap.	chapter (not Ch.)
CHNC	convoluted or hypernetted chain (theory); classical-map hypernetted chain (always ask author to verify]
CHSH	Clauser-Horne-Shimony-Holt
CI	configuration interaction, confidence interval
*C.L.	confidence limits (standard statistical abbreviation) (in tables)

CL	closed loop; conversion loss control language; confidence level (expressed as a percentage)
c.m.	(i) center of mass (do not define, but spell out in title] (ii) center of momentum
CMA	cylindrical mirror analyzer
CMN	cerium magnesium nitrate
CMOS	complementary metal-oxide semiconductor
c.m.s.	center-of-mass system (change to c.m. system or define]
CN	type designation for Van de Graaff electrostatic accelerator
CNDO	complete neglect of differential overlap
CNO	carbon-nitrogen-oxygen (cycle) (in stars)
CNT	carbon nanotube
*Co.	Company
CO	crystalline orbital
*coeff	coefficient (in subscript)
COLTRIMS	cold-target recoil-ion momentum spectroscopy
const	constant (used only as part of expression: const $\gamma^6 =$ const $\times$ γ^6; both OK]
*Corp.	Corporation
*cp	chemically pure
c.p.	cyclic permutation (define, but not if used in an equation]
**CP*	(charge conjugation) X parity
*C.P.	commercially pure
CPA	coherent potential approximation
*cpd	contact potential difference
**CPT*	(charge conjugation) x parity X (time reversal) (also *PCT*, *TCP*]
*CPU	central processing unit (do not define]
cQED	compact quantum electrodynamics
CREI	charge-resonance enhanced ionization
CRN	continuous random network
CRO	cathode-ray oscilloscope
CRT	cathode-ray tube
CSP	channel substrate planar
CSRO	compositional short-range order
CS	Chern-Simons
CT	charge transfer
*cu	cubic
CV, *C-V*	capacitance-voltage
CVC	(i) conserved vector current (ii) Consolidated Vacuum Corp.
CVD	chemical vapor deposition
*cw	continuous wave
CW	clockwise

CWZ	Coleman-Wess-Zummo
Cz	Czochralski
D/A, DA	digital-analog
DAC	digital-to-analog converter
DAG	dysprosium aluminum garnet (change to DyAIG]
DBR	distributed Bragg reflector
*dc	direct current
DESY	Deutsches Elektronen-Synchrotron
*dev	deviation
DF	Dirac-Fock
DFB	distributed feedback
DFT	(i) density-functional theory (ii) discrete Fourier transform
DGS	Deser-Gilbert-Sudarshan
DH	double heterostructure
dhcp	double hexagonal-close-packed (define as “double hep”]
dHvA	de Haas–van Alphen (use an en dash)
DI	de-ionized
diam	diameter (spell out, except in phrases like “the 4-in.-diam tube”]
DiFF	dihedron fragmentation functions
DLA	diffusion-limited aggregation (or aggregate]
DLC	diamondlike carbon
DLTS	deep-level transient spectroscopy
DLY	Drell-Levy-Yan
DMA	direct memory access
DMRG	density-matrix renormalization group
*DNA	deoxyribose nucleic acid
DOF, d.o.f.	degree of freedom
DOS	density of states
dpa	dose per atom
DPCMA	double-pass cylindrical mirror analyzer
DPDT	double-pole double-throw (switches)
DPPH	diphenylpicrylhydrazyl
*Dr.	Doctor (in acknowledgments) [do not pluralize to Drs. (write “Dr. Smith and Dr. Jones...”)]
DRAM	dynamic random access memory
DRM	dual resonance model
DSAM	Doppler-shift attenuation method
DSC	differential scanning calorimetry
DTA	differential thermal analysis
DTCA	differential thermal-conductivity analysis
DWBA	distorted-wave Born approximation
DWIA	distorted-wave impulse approximation

DZ+P	double zeta plus polarization
*E	east
E.A.,EA	electron affinity
EAPFS	extended appearance-potential fine structure
EARS	enhanced adsorbate Raman scattering
EBIC	electron-beam-induced current
EC	electron capture [define, except in contexts (tables and reaction symbols) where it alternates with a, (J, etc., and obviously means a decay mode]
ECPSSR	perturbed-stationary-state (PSS) theory with energy-loss (E), Coulomb deflection (C), and relativistic (R) corrections
ECS	exterior complex scaling
*ed.	edition (in references) (not for “edited,” which should be spelled out]
EDAX	energy dispersive x-ray analysis
EDC	energy distribution curve
EDM	electric dipole moment
EDPD	energy-dependent photoelectron diffraction
EDS	energy dispersive spectroscopy
EDTA	ethylenediamine tetra-acetic acid
EELS	electron-energy-loss spectroscopy
EFG	(i) electric field gradient (or efg) (ii) edge-defined film-fed growth
*e.g.	*exempli gratia* (“for example”) [Use “E.g."at beginning of sentence (“For example” looks better, especially in text); not interchangeable with i.e.]
eGP(E)	extended Gross-Pitaevskii (equation)
EIA	electromagnetically induced absorption
EIS	eikonal initial state
EIT	electromagnetically induced transparency
*el	elastic (in subscript)
ELEED	elastic low-energy electron diffraction
em, e.m.	electromagnetic
EM, E.M.	Einstein-Maxwell (EM)
EMA	(i) effective-mass approximation (more common meaning) (ii) effective-medium approximation
*emf	electromotive force (PRA/E: define)
EMTO	extended muffin-tin orbital
*EN	type designation for Van de Graaff electrostatic accelerator

ENDOR	electron-nuclear double resonance [define (but spell out in titles unless awkward)]
EOS	equation of state
EPM	empirical pseudopotential method
EPR	(i) electron paramagnetic resonance (leave spelled out in titles unless awkward] (ii) Einstein-Podolsky-Rosen (in most cases this is what it stands for in Phys. Rev. A, always when followed by "pair", "paradox", etc., but usually even if it stands alone]
Eq.	equation (not mandatory before equation numbers in text, but recommended in "the expression for *L* [Eq. (6)]" and spell out Equation at the beginning of a sentence.
EQ	equivalent quantum
equiv.	equivalent
erf, erfc	error function
ERK/MAPK	as in "ERK/MAPK pathway" (slash is allowed). ERK (extracellular signal-regulated kinase) and MAPK (mitogen-activated protein kinases) should be defined previously.
ERT	effective-range theory
ESCA	electron spectroscopy for chemical analysis
*e.s.d.	estimated standard deviation
ESEEM	electron spin echo envelope modulation
ESR	electron spin resonance (leave spelled out in titles unless awkward]
**et al.*	*et alii* ("and others") [is plural ("Jones *et al*." not to be used for "Jones and Smith")]
ETC	equal-time commutator
ETCR	equal-time commutation relation
*etc.	*et cetera* ("and other things," "and so on")
**et seq.*	*et sequens* ("and the following one"), *et sequentes* ("and those that follow") [often mistakenly used for "and following" (if so used, replace with "and following"); cf. ff]
EUV, euv	extreme ultraviolet (for PRA/E, do not define; euv also allowed)
EWSR	energy-weighted sum rule
EXAFS	extended x-ray-absorption fine structure
*expt	experiment (al) (in subscript) [not exp ("exponential"); use "Expt." as column heading]
**f*/16	aperture ratio 16 (not f:16 or f-16 or F 16]
FC	Franck-Condon
*fcc	face-centered-cubic

FEM	field-emission (or electron) microscopy
FESR	finite-energy sum rule (s)
FET	field-effect transistor (in electronics)
*ff	“and following (pages)” (in references) [“p. 107ff means “p. 107 and following” (but it is better to be precise: pp. 107-109)]
FF	fill factor
FFT	fast Fourier transform
*Fig.	figure (write out when first word of a sentence)
fil. lic.	Swedish degree (equivalent of Ph.D.) (delete from byline]
FIM	field-ion microscopy
FK	Fermi-Kurie (analysis, plot)
*FM	frequency modulation
*FN	type designation for Van de Graaff electrostatic accelerator
FQHE	fractional quantum Hall effect
FRM	ferromagnetic resonance
FROG	frequency-resolved optical gating
FRW	Friedmann-Robertson-Walker
f.s.	full-scale
FS	Fermi surface
FSE	finite-size effect
FSR	free spectral range
(F)FT	(fast) Fourier transform
FTIR	Fourier transform infrared
*FWHM	full width at half maximum
FWM	four-wave mixing
FZ	floating zone (technique for crystal growth)
GDR	giant dipole resonance
GGA	generalized gradient approximation
GGG	gadolinium gallium garnet
GHZ	Greenberger-Horne-Zeilinger
GI	Geshkenbein-Ioffe
GID	grazing incidence x-ray diffraction
GLAG	Ginzburg-Landau-Abrikosov-Gor'kov
GLPC	gas-liquid-phase chromatography
G.M.	Geiger-Muller (tube, counter)
GMOR	Gell-Mann–Oakes-Renner
GNS	Gel'fand-Naimark-Segal
Gp	group
GP	Guinier-Preston (zones)
GP (E)	Gross-Pitaevskii (equation)
GQO	giant quantum oscillation

g.s.	ground state [define, except when part of reaction symbol: $Cr^{52}(p,d)\ Cr^{51}$g.s.)]
GT	(i) Gamow-Teller (in nuclear theory); (ii) Goldberger-Treiman (in SU theory)
GTO	Gaussian-type orbital
*GW	Hedin's GW approximation (PRA/E: define)
GW	Product of G (Green's function) and W (interaction)
H	heavy (for mass-number group) (cosmic-ray nuclei) (italic to contrast with element abbreviations)
*H.a.	Hermitian adjoint
HBC	hydrogen bubble chamber
*H.c.	Hermitian conjugate
*hcp	hexagonal-close-packed
*HD	hydrogen deuteride
hf	(i)high frequency; (ii) hyperfine (structure, splitting, interaction)
HF	Hartree-Fock
HFB	Hartree-Fock-Bogoliubov (theory, equations)
HF(S)(R)	Hartree-Fock (-Slater) (-Roothaan)
HFBR	high-flux-beam reactor
HFIR	high-flux-isotope reactor
hfs	hyperfine structure
HHG	high-harmonic generation, high-order-harmonic generation (PRA/E prefers), (PRA/E: if authors argue we will allow "high-order harmonic generation)
HI	heavy-ion (define, except when used in nuclear reaction symbols]
HILAC	heavy-ion linear accelerator
HIPAC	high-energy particle accelerator
HNC	hypernetted chain
HOMO	highest occupied molecular orbital
HOPG	highly oriented pyrolytic graphite
HP	Hewlett-Packard (company name)
HPS	(i) hyperfine pressure shift; (ii) horizontal parallel slits
HREELS	high-resolution electron-energy-loss spectroscopy
HS	(i) Hartree-Slater; (ii) Hubbard-Sham
HSCC	hyperspherical close-coupling (method)
HV	high-voltage (source, pulse, power supply)
HVEM	high-voltage electron microscopy
HWHM	half width at half maximum
I	insulator (in designations of sandwiches) [define; "Sn-*I*-Sn" (must be italic, since roman I means iodine)]

I	Paper I in series (II for Paper II, etc.) [define, with long definition:(hereafter referred to as I); often defined in an early reference]
IA	impulse approximation
IAC	independent atomic center
IACS	International Annealed Copper Standard
**ibid.*	*ibidem* (“in the same place”) (in references but no longer used in Phys Rev.)
IC	integrated circuit
ICC	internal-conversion coefficient (ii) intra-atomic correlation correction (theory)
ICF	inertial confinement fusion
*ICI	Imperial Chemical Industries
ICP	inductively coupled plasma
*ICT	International Critical Tables
i.d.	inside diameter (define, except in phrases like “the 4-in.-i.d. tube”)
iDMRG	infinite density matrix renormalization group
*i.e.	*id est* (“that is”) [use “I.e.” at beginning of sentence (“That is” looks better, especially in text. Other options: Specifically…, In other words…); not interchangeable with e.g.]
*I.E.	ionization efficiency
*i.f.	intermediate frequency
iff	“if and only if” (in math) [spell out (or define if used very often)]
IHLG	inhomogeneous Lorentz group
ILEED	inelastic low-energy electron diffraction
*Im	imaginary
*Inc.	Incorporated
*inel	inelastic (in subscript)
INS	ion neutralization spectroscopy
I/O	input-output ports
*IP	ionization potential (PRA/E: define) Replace by V_i in equations.
IPM	independent-particle model
i.p.s.	impulses per second
*ir, IR author choice	infrared
IR	current x resistance (drop)
IR	(i) infrared, (ii) irreducible representation
i.s.	isomer shift
ISO	imaginary spin orbit
ISR	intersecting storage rings

ISS	ion scattering spectroscopy
IT	isomeric transition
IUPAC	International Union of Pure and Applied Chemists
IUPAP	International Union of Pure and Applied Physicists
**IV*, *I-V*	current-voltage (plot, characteristic)
J	(i) iodine (used by some Germans-change to I); (ii) joule
JCPDS	Joint Committee for Powder Diffraction Standard
JLD	Jost-Lehmann-Dyson
jnd	just noticeable difference
*JWKB	Jeffreys-Wentzel-Kramers-Brillouin
*JWST	James Webb Space Telescope (author choice to define or not)
KDP	potassium dihydrogen phosphate
KdV	Korteweg–de Vries
KE	kinetic energy (KE is an abbreviation only, not a "symbol")
KER	kinetic-energy release
KFR	Keldysh-Faisal-Reiss
KG	Klein-Gordon (equation)
KK	Kramers-Kronig (analysis)
KKR	Korringa-Kohn-Rostoker (method for energy bands in metals)
KLI	Krieger-Li-Iafrate (in density-functional theory)
KS	Kohn-Sham (in density-functional theory)
KSRF	Kawarabayashi-Suzuki-Riazuddin-Fayyazuddin (relations) define; not KFSR
kVp	kilovolt (peak) (x-ray notation) change to kV(peak)
L	light (for mass-number group) (cosmic-ray nuclei) (italic to contrast with element abbreviations)
*LA	longitudinal-acoustic(al) (PRA/E: define)
lab	laboratory (in subscript) (spell out in text)
*lat	latitude
**LC*, *L-C*	inductance-capacitance (integrator, circuit, filter, time constant)
LCAO(-MO)	linear combination of atomic orbitals (-molecular orbitals)
LCMTO	linear combination of muffin-tin orbitals
LCP	left-circularly polarized (electric field)
**LCR*	inductance-capacitance-resistance (integrator, circuit, filter, time constant)
LDA	local-density approximation (OK to not to spell out in title)
LDOS	local density of states
LEC	liquid-encapsulated Czochralski
LED	light-emitting diode
LEED	low-energy electron diffraction (OKto not to spell out in title)
LG(W)	Landau-Ginzburg (-Wilson)
LGaG	lutetium gallium garnet

LHBC	liquid-hydrogen bubble chamber (spell out)
l.h.c.	left-hand circular (polarization)
LHeT	liquid-helium temperature
lhs, LHS	left-hand side (spell out or, if used often, define. LHS preferred)
LIF	laser-induced fluorescence
LJ	Lennard-Jones
LMTO	linear muffin-tin orbital
LNT	liquid-nitrogen temperature
*LO	longitudinal-optic(al) (PRA/E: define)
loc. cit.	*loco citato* (“in the place cited”) (in references) (do not use)
LOCC	local operations and classical communication
LOCOS	localized oxidation of silicon
LPC	linear predictive coding
LPCVO	low-pressure chemical vapor deposition
LPE	liquid-phase epitaxy
LRO	long-range order
**LS*	*L* and *S* are quantum numbers (*LS* coupling)
LSB	least significant bit
LSDA	local spin-density approximation
LSF	least-squares fit
LSS	Lindhard-Scharff-Schiott
LST	Lyddane-Sachs-Teller
LSZ	Lehmann-Symanzik-Zimmermann
LTE	local thermodynamic equilibrium
LUMO	lowest unoccupied molecular orbital
LXTT	Lang x-ray transmission topography
M	medium (for mass-number group) (cosmic-ray nuclei) (italic to contrast with element abbreviations)
MAPK/ERK	A biological pathway. MAPK = mitogen-activated protein kinases, ERK = extracellular signal-regulated kinases. Slash is allowed. The two acronyms should be defined in text before using the full expression
MAS	magic angle spinning
*max	maximum (in subscript)
MBE	molecular beam epitaxy
MC	(i) Monte Carlo; (ii) mode conversion
MCA	multichannel analyzer
MCDF	multiconfiguration Dirac-Fack (method)
MCHF	multiconfiguration Hartree-Fock (procedure)
MCP	multichannel plate
MCSCF	multiconfiguration self-consistent-field (method)
MCS/s	Monte Carlo steps per site
MCTDH(F)	multiconfiguration time-dependent Hartree (-Fock)

MD	molecular dynamics
MESFET	metal-semiconductor field-effect transistor
mfp, MFP	mean free path
**MH*, *M-H*	magnetization-magnetic-field (loops on oscilloscope)
MHD	magnetohydrodynamics
*min	minimum (in subscript); minute
MIS	metal-insulator-semiconductor
*mks	meter-kilogram-second (system)
ML	monolayer
MLT	mass-length-time
MM	missing mass [define; use parens for clarity in equations: m + MM, but $(MM)^2$, except in context of particle reactions: $K^- p \rightarrow \pi^+ \pi^- MM$]
*mmf	magnetomotive force
MNDO	modified neglect of differential overlap
MO	molecular orbital
MOCVD	metal-organic chemical-vapor deposition
MODFET	modulation-doped field-effect transistor
*mol	(i) molecule (in subscript) (discouraged as abbreviation for molecule, but do not write it out unless certain it means molecule) (ii) mole
MOS	metal-oxide-semiconductor (junction)
MOSFET	metal-oxide-semiconductor field-effect transistor
MOT	magneto-optical trap
*mp	melting point
*MP	(i) type designation for Van de Graaff electrostatic accelerator; (ii) Møller-Plesset (often followed by a number: MP2 = “second-order Møller-Plesset”)
*MPM	mole percent metal
MR	magnetoresistance
MRI	(i) modified-rigid-ion (model); (ii) magnetic resonance imaging
MR(SD)CI	multireference (single double) configuration interaction
MTR	Materials Testing Reactor (spell out)
MUB	mutually unbiased basis
MXPS	monochromated x-ray photoelectron spectroscopy
*N	(i) north (ii) nitrogen (iii) newton (iv) “nines” (trade jargon: 4N = 99.99%) [change to numbers (“3N purity stock” becomes “99.9%-purity stock”)]
NA	numerical aperture
NAH	near-field acoustical holography

*N.B.	*nota bene* (“mark well”) (looks good set off independently; may begin a paragraph or precede a sentence)
*N.D.	not determined (in tables)
NDE	nondestructive evaluation
*Nd:YAG	Nd-doped yttrium aluminum garnet
NE	negative-energy (mode)
NES	neodymium ethyl sulfate (define; better, change to $NdEtSO_4$)
NEXAFS	near-edge x-ray-absorption fine structure
NLSE	nonlinear Schrödinger equation (sometimes, though not as frequently, also abbreviated as NSE)
NMOS	*n*-type metal-oxide semiconductor
NMR	nuclear magnetic resonance (do not define, but leave spelled out in titles unless awkward)
NN	nearest neighbor (not nn or n.n.)
NNN	next nearest neighbor
*No.	number [use after Contract, Grant, and Report and before number: Contract No. HC 1667; awkward in “Wratten filter No. 5” and “sample No. 2” (“Wratten filter 5” and “sample 2” sufficient); not #]
*NOON	(state) maximally path entangled (|N,0> + |0,N>) (OK in titles too)
*NP	nondeterministic polynomial (set as NP-complete, NP-hard)
**N-P-T*	“in the space of number of molecules, pressure, and temperature” (“*N-P-T* ensemble”)
NQR	nuclear quadrupole resonance
NRA	nuclear reactions analysis
NTP	normal temperature and pressure (same as STP) (use STP)
NUT	Newman-Unti-Tamburino
nvt	(number density) × velocity × time (designation of particle fluence) (“fluence *nvt* of 3 ×109 cm^{-2}”) (is the name of a quantity, not a unit, and the true unit must be mentioned)
NWSZ	nonsense wrong-signature zero
OBE	one-boson exchange
OBEC	one-boson exchange contribution
OBEP	one-boson exchange potential
*obs	observed (in subscript) (use Obs. as column heading)
o.d.	outside diameter (spell out, except in phrases like “the 4-in.-o.d. tube”)
OD	(i) optical density; (ii) optical depth
ODLRO	off-diagonal long-range order
OEP	optimized effective potential (often in connection with SIC)
o.f.,O.F.	optical frequency
OFHC	oxygen-free high-conductivity copper (usually)
OMA	optical multichannel analyzer

OMCVD	organometallic chemical-vapor deposition
omg	optical-metastable-ground state (after optical-frequency (*o*), metastable-state (*m*), and ground-state (*g*) qubits) as in *omg* architecture
OMS	optical modulation spectroscopy
OMVPE	organometallic vapor-phase epitaxy
op. cit.	*opere citato* (“in the work cited”) (in references) (do not use)
OPE	one-pion exchange
OPEA	absorption-modified one-pion exchange
OPEC	one-pion exchange contribution
OPEP	one-pion exchange potential
OPW	orthogonalized plane wave
*p	page (spell out at beginning of sentence; not pg.; cf. pp.)
P, P	principal value (before integral sign) [define (P better if *P*'s around) or P.V. (define); or $\mathscr{P}$ (define)]
PAC	perturbed angular correlation
PASS	parametric amplification sampling spectroscopy
PBE	Perdew-Burke-Ernzerhof (functional)
p.c., PC	parity conserving
PCAC	partial conservation of (or partially conserved) axial-vector current (not “currents”)
**PCT*	parity x (charge conjugation) x (time reversal) (also *CPT*, *TCP*)
PCTC	partial conservation of tensor currents
PCVC	partially conserved vector current
*PD	potential difference
PDF	pair distribution function
PDOS	(i) partial density of states (most common meaning); (ii) phonon density of states; (iii) projected density of states
*pe	probable error
PE	(i) parabolic equation; (ii) paraelectric
PECVD	plasma-enhanced chemical-vapor deposition
PEPECO	photoelectron-photoelectron coincidence
PEPICO	photoelectron-photoion coincidence
PEPR	precision encoding and pattern recognition (device)
PES	(i) photoemission spectroscopy; (ii) photoelectron spectroscopy; (iii) potential energy surface
PET	(i) personal electronic transfer (rarely); (ii) photoinduced electron transfer, (iii) positron emission tomography; (iv) Polyethylene terephthalate (a common plastic material; do not define)
p-h	particle-hole [define (roman to distinguish from p for proton)]
*pH	a measure of acidity or alkalinity (not *p*H)

PHA	pulse-height analyzer (or “kicksorter”)
*Ph.D.	Doctor of Philosophy (“Ph.D. thesis” in references) (delete from byline)
PHI	physical electronics instrument
PIA	peripheral interface adapter
**p-i-n*	positive-intrinsic-negative (structures) (semiconductors)
PIPICO	photoion-photoion coincidence
PLD	periodic lattice distortion
PLEED	polarized low-energy electron diffraction
*p.m.	post meridiem
PM	(i) pulse-modulated (signals); (ii) photomultiplier (tube)
PME	photomagnetoelastic
PMT	photomultiplier tube
PNC	parity nonconservation
POVM	positive operator-valued measure
*pp	pages (Use “Pages” at beginning of sentence, not Pp.)
*p.p., p.-p.	peak to peak (“400 V p.p.”)
PPT	positive partial transpose
**PPV*	pseudoscalar-pseudoscalar-vector (coupling)
PQR	pure quadrupole resonance
PRF	pulsed repetition frequency
PRFE	polar-reflection Faraday effect
Prof.	Professor (in acknowledgments) [spell out (use in singular only: “Professor Jones and Professor Smith...”)]
PROM	programmable read-only memory
*Ps	positronium
PSD	(i) pulse-shape discrimination (or . . . discriminator); (ii) phase-sensitive detection; (iii) photon-stimulated desorption, (iv) position-sensitive detector (often)
PSG	phosphosilicate glass
*Pt.	Part (in references)
**PT*	parity-time (italic or calligraphic font, not roman)
PTC	(i) positive-temperature-characteristic (resistivity); (ii) psychophysical tuning curve
ptp	peak to peak (spell out)
p.v., PV	parity violating
*P.V., PV	principal value (see *P*, P) (PRA/E: spell out in text, change to roman-font P in equations)
PVT	physical vapor transport
PWBAE	plane-wave Born approximation with exchange
PY	Percus-Yevick
PZT	(i) piezoelectric transducer; (ii) lead zirconic titanate

*QCD	quantum chromodynamics
*QED	quantum electrodynamics
*Q.E.D.	*quod erat demonstrandum* (“which was to be demonstrated”) (formally concludes a proof) (looks good set off like a sentence)
QFT	quantum field theory
QKD	quantum key distribution
QMA	quadrupole mass analyzer
QMS	(i) quadrupole mass spectrometer; (ii)quartz monitoring system
QRPA	quasirandom-phase approximation
QS	quadrupole splitting
QSTD	quasiparticle second Tamm-Dancoff
QTD	quasiparticle Tamm-Dancoff
RABBITT	reconstruction of attosecond beating by interference of two-photon transitions
RAM	random access memory
RAPW	relativistic augmented plane wave
RBS	Rutherford backscattering spectroscopy
**RC*, *R-C*	resistance-capacitance (integrator, circuit, filter, time constant)
RCP	right-circularly polarized
*Re	real
RE	rare earth (define; may be used as in RE^{3+})
REEL	reflection-electron energy loss (define) (cf. TEEL)
REELS	reflection-electron energy-loss spectroscopy
*Ref.	reference (write out when first word of sentence)
REM	reflection electron microscopy
REMPI	resonantly enhanced multiphoton ionization
* rf	radio frequency
RFSE	radio-frequency size effect
r.h.c.	right-hand circular (polarization)
RHEED	reflection high-energy electron diffraction
RHF	relativistic Hartree-Fock
rhs, RHS	right-hand side (spell out or, if used often, define)
RIBE	reactive ion-beam etching
RIMS	recoil-ion momentum spectroscopy
RK(K)Y	Ruderman-Kittel (-Kasuya) -Yosida
*rms	root-mean-square
*RNA	ribonucleic acid
ROM	read-only memory
ROPW	relativistic orthogonalized plane wave
RPA	random phase approximation

RPAE	random-phase-approximation exchange
RPD	retarding potential difference
RRPA	relativistic random-phase approximation
RRR	residual resistivity ratio
RS	rocksalt (crystal structure)
RSJ	resistively shunted junction
*RT	room temperature (PRA/E: define)
RWA	rotating-wave approximation
*S	south
SAD	selective area diffraction
SANS	small-angle neutron scattering
SAW	surface acoustic wave
SAXS	small-angle x-ray scattering
SBH	strip-buried heterostructure
SBZ	surface Brillouin zone
sc	simple cubic (lattice)
SCCM	cubic centimeter per minute at STP
SCA	(i) single-channel analyzer; (ii) semiclassical approximation
SCE	standard calomel electrode
SCF	self-consistent field
SCLS	surface core-level shifts
scope	oscilloscope (spell out)
SCR	silicon-controlled rectifier
s.d., SD	standard deviation
SDW	spin-density wave
*Sec.	section (write out when first word in sentence)
SEM	(i) secondary-emission monitor; (ii) scanning electron microscopy (or microscope)
*Ser.	Series (in references)
SERS	surface-enhanced Raman scattering
SEXAFS	surface-extended x-ray-absorption fine structure
SFA	strong-field approximation
shf	superhyperfine
SHG	second-harmonic generation
SHPi(o)	superhydrophilic (phobic)
SI	(i) Système International (International System of units); (ii) surface ionization
SIC	self-interaction correction
SIMS	secondary-ion-mass spectroscopy
SIP	strongly interacting particle [define (“hadron” is better)]
SL	sensation level
SLOCC	stochastic local operations and classical communication
SMP	scanning measuring projector

SN(R), S/N	signal-to-noise (ratio) [define (should always be followed by "ratio"); in equations use $R_{S/N}$"]
SO, S.O., s.o., so	spin orbit
SOI	silicon-on-insulator
SOS	silicon-on-sapphire
sp	square planar (lattice)
SPA	shielded-potential approximation
SPC/E	extended simple point charge
*SPDT	single-pole double-throw (switches)
SPE	(i) solid-phase epitaxy; (ii) stimulated photon echo
spec	spectroscopically ("spectroscopically pure") (spell out)
*sp. gr.	specific gravity
SPhP	surface phonon polariton
SPIDER	spectral phase interferometry for direct electric-field reconstruction
SPL	sound pressure level
*sq	square
SQUID	superconducting quantum interference device
SRC	Scientific Research Council
SRO	short-range order
SSXA	surface soft-x-ray absorption
s.t.	such that, so that (spell out)
S.T.	Schwinger term
STEM	(i) scanning transmission electron microscopy; (ii) scanning-tunneling electron microscopy (or . . . microscope)
stereo	stereoscopic ("stereoscopic triads") (in bubble chamber) (spell out)
STIRAP	stimulated Raman adiabatic passage
STM	scanning tunneling microscope (or . . . microscope)
STO	Slater-type orbitals
*STP	standard temperature and pressure
**SUB*	*S*, *U*, *B* are quantum numbers ("*SUB* model") (in symmetry theory)
*Suppl.	Supplement (in references)
SVP	saturated vapor pressure
SW	spherical wave
SWCNT	single-wall carbon nanotube
SWG	(i) Standard Wire Gauge; (ii) Stubbs Wire Gauge
SWR	standing-wave radio
SXA	soft x-ray absorption
SXAPS	soft x-ray appearance-potential spectroscopy
SXPS	soft x-ray photoemission spectroscopy
sync	synchronization ("synchronization pulse") (spell out)
*TA	transverse-acoustic (PRA/E: define)

TAC	time-to-amplitude converter (same as TPHC)
Taub-NUT	Taub-Newman-Unti-Tamburino [define “the Taub-NUT (Taub-Newman- ...) results ...”]
TCNQ	tetracyanoquinodimethane
**TCP*	(time reversal) x (charge conjugation) x (parity) (also *CPT*, *PCT*)
TDA	Tamm-Dancoff approximation
TDCC	time-dependent close-coupling (method)
TDDFT	time-dependent density-functional theory
TDHF	time-dependent Hartree-Fock
TDMRG	time-dependent density matrix renormalization group
*TE	transverse-electric (model) (“TE_{100}”) (PRA/E: define)
TEA	transversely excited atmosphere
TED	transmission electron diffraction
TEEL	transmission-electron energy loss
*TEM	transverse-electromagnetic (mode) (“TEM_{100}”)
TF	Thomas-Fermi
TFD	Thomas-Fermi-Dirac
TF-TCNQ	tetrafluoro-tetracyanoquinodimethane
TGA	thermogravimetric analysis
TGS	triglycine sulfate
*Th*C*	decay product of thorium [also Th*C’*, Th*C”*; be sure ThC (thorium carbon compound) not meant]
Ti:Sa	always set as Ti:sapphire [spell out (lowercase) sapphire]
*theor	theory, theoretical (in subscript) (use “Theor.” as column heading)
TJS	transverse junction stripe
TL	transmission loss
TLM	transmission line method
*TM	transverse-magnetic (mode) (“TM_{100}”) (PRA/E: define)
TMC	Technical Measurement Corp. (spell out)
*TO	transverse-optic(al) (PRA/E: define)
TOF	time-of-flight
*tot	total (in subscript)
TPC	time-to-pulse-height converter (same as TAC)
TPE	two-pion exchange
TPHC	time-to-pulse-height converter (same as TAC)
TS	threshold shift
TSRO	topological short-range order
TTL	transistor-transistor logic
TW	Taylor-Weinberg
TWT	traveling-wave tube
Tx	tracks (spell out]

UFI	universal Fermi interaction
*uhf	ultrahigh-frequency
UHF	unrestricted Hartree-Fock (atomic structure) [define (be sure uhf not meant)]
uhp	ultrahigh plurity
*UHV	ultrahigh vacuum
UIR	unitary irreducible representation
UPE	universal particle exchange
UPR	ultrasonic paramagnetic resonance
UPS	ultraviolet photoemission spectroscopy
*URCA	type of process (in astrophysics)
*UT	universal time
*uv, UV	ultraviolet (author choice)
* V-A	vector minus axial-vector (theory)
*VB	valence band (PRA/E: define)
VBM	valence-band maximum
VDM	vector-dominance model
VESCF	variable electron negativity concept
VEV	vacuum expectation value
VFC	voltage frequency converter
VFO	variable-frequency oscillator
VFZ	vacuum-float-zone
VH	very heavy (for mass-number group) (cosmic-ray nuclei) (italic to contrast with element abbreviations)
*VHF	very-high frequency (PRA/E: define)
*viz.	*videlicet* (“that is to say,” “namely”) [should not begin a sentence (“That is,” “That is to say” are good substitutes)]
**VL*	very light (for mass-number group) (cosmic-ray nuclei) (italic to contrast with element abbreviations)
*VLF	very-low-frequency
VLSI	very large scale integrated (circuit)
VMD	vector-meson dominance
*Vol.	Volume (in references)
*VPC	vapor-phase chromatography
VPE	vapor-phase epitaxy
VPS	vertical parallel slits
vs	versus (follow author for versus or vs but spell out in titles and in headings; vs always in captions; not vs.)
VSM	vibrating-sample magnetometer
PSWR	voltage standing-wave ratio
VTVM	vacuum-tube voltmeter
VUU	Vlasoz-Uehling-Uhlenbeck
*vuv, VUV	vacuum ultraviolet (author choice)
V.V.	vice versa (spell out)

*VYNS	trade name for a polyvinyl-acetate-chloride copolymer
*W	west
WDS	wavelength dispersive spectroscopy
WDST	Word Data Summary Tape
WDX	wavelength dispersive x-ray analysis
we, w.e.	water equivalent
w.f.	wave function
WF	work function
*WKB(J)	Wentzel-Kramers-Brillouin(-Jeffreys)
w.r.t.	“with respect to” (spell out)
WS	Wigner-Seitz (cell)
WU	wurtzite (crystal structure)
XAFS	x-ray absorption fine structure
XANES	x-ray absorption near-edge structure
XAS	x-ray absorption spectroscopy
XES	x-ray emission spectroscopy
XFEL	x-ray free-electron laser
**XPM*	*X*, *P*, *M* refer to variables X^{μ}, P^{μ}, *M* (“*XPM* algebra”)
XPS	(i) x-ray photoemission spectroscopy; (ii) x-ray photon spectroscopy
XRD	x-ray diffraction
XTEM	cross-section transmission electron microscopy
*xuv, XUV	extreme ultraviolet (author choice)
YAG	yttrium aluminum garnet
YGaG	yttrium gallium garnet
YIG	yttrium iron garnet
*Y-IV	Yale calculation IV (in nuclear scattering)
*YLAM	name of physical property
Z.B.	(i) zone boundary; (ii) zinc-blende (crystal structure)
ZGS	zero-gradient synchrotron

Roman Functions

Function	Meaning
Ai, Bi	Airy integrals
arccos	arccosine
arccot	arccotangent
arccsc	arccosecant
arcsec	arcsecant
arcsin	arcsine
arctan	arctangent
Ci	first cosine integral
cos	cosine
cosh	hyperbolic cosine
cov	covariance
csc	cosecant
det	determinant
Det	functional determinant
diag	diagonal (matrix)
dim	number of dimensions
div	divergence
erf	error function
erfc	complement of error function
exp	exponential
grad	gradient
Im	imaginary part (not $\Im$)
lim	limit
ln	logarithm (natural, base e)
log	logarithm (indicate the base)[a]
max	maximum
min	minimum
o	of order less than
O	of the order of (not script); the

	argument always and only goes in parens: O(r(m,μ))
P or P.V.	principal value (define; use roman if other P's; usually appears before an integral)
Prob	probability function
Re	real part (not ℜ), not real value
sgn	signum
Si	first sine integral
sin	sine
sinh	hyperbolic sine
tan	tangent
tanh	hyperbolic tangent
ϑ	ϑ function (use curly theta)
Θ	Θ function (use aitch theta)
Tr, tr	trace
zn	Jacobian ζ function

Units of Measure

Units marked with asterisks are base, derived, or supplementary units of the *Systeme International.*

A B C D E F G H I J K L M N O P Q R S T U V W X Y X

A

abampere – spell out

abohm – spell out

abvolt – spell out

amagat – spell out

*ampere – A

ampere hour – A h

ampere turns per meter – At/m

angstrom – Å

arc minute – arc min

astronomical unit – AU

atmosphere – atm

atmosphere, standard – A_s

atomic mass unit – u

atomic parts per million – at. ppm

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atomic percent – at. %

atomic time unit – atu

atomic unit- a.u.

attofarad – aF

bar – spell out (bars if more than one, but mbar, kbar, etc., always singular)

bark – spell out

barn – b

barye – spell out

biot – Bi

bit or bits – spell out

blobs per hundred microns – blobs/(100 μm)

bohr – spell out

British thermal unit – Btu

bytes – spell out

calorie – cal

*candela – cd

candelas per square meter – cd/m^2

candlepower – cp

centimeter – cm

centipoise – cP

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*coulomb – C

counts per minute – counts/min, cpm

counts per second – counts/s

cubic centimeter – cm^3 (cc discouraged)

curie – Ci

cycle – spell out, c

cycles per second – cps, c/s

day d, – or spell out

debye – D

decibel – dB, dBm

degree – °, deg [use (deg) in table headings]

degrees Baumé– °B

degrees Celsius– (centigrade) °C

degrees Fahrenheit– °F

degrees Kelvin– K

disintegrations per minute – dis/min

disintegrations per minute per microgram – dis/min μg

disintegrations per second – dis/s

dyne – dyn

electromagnetic unit – emu

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electron barn – *e* b

electrons per atom – *e*/at.

electrons per cubic centimeter – e/cm^3, $e\ cm^{-3}$

electron unit – e.u.

electron volt – eV

electrostatic unit – esu

entropy unit – eu

erg – spell out

*farad – F

femtofarad – fF

femtometer – fm

fermi – F

fissions per minute – fpm

foot – ft (not ft.)

foot-candle – fc

foot-lambert – fL

foot-pound – ft lb (not ft. lb.)

formula units – f.u.

franklin – Fr

gal – Gal (unit of gravitational force)

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centistoke – cS

gallon – gal

gauss – G

gibbs – spell out

gigacycles per second – Gc/s

giga-electron-volt – GeV

gigahertz – GHz

gigavolt – GV

gilbert – Gi

gram – g

hartree – spell out [never H, as in mH (should be mhartree)]

hectogram – hg

*henry – H

*hertz – Hz

horsepower – hp

hour – h

inch – in.

*joule – J

kayser – K

*kelvin – K

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kilobar – kbar

kilobyte – kbyte

kilocalorie – kcal

kilocycles per second – kc/s

kilodegrees kelvin – kK

kilodyne – kdyn

kilo-electron-volt – keV

kilogauss – kG

*kilogram – kg

kilogram force – kgf

kilogram meter – kg m

kilohertz – kHz

kilohm – kΩ

kilojoule – kJ

kilomegacycles per second – kMc/s

kilometer – km

kilo-oersted – kOe

kiloparsec – kpc

kilosecond – ks,ksec

kiloton – kt

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kilovolt – kV

kilovolt ampere – kV A

kilowatt – kW

kilowatt hour – kW h

knot – kn

lambert – L

langmuir – L

liter – l

Lorentz unit – LU

*lumen – lm

lumens per watt – lm/W

*lux – lx

Mach – M

maxwell – Mx

megahertz – MHz

megacycles per second – Mc/s

mega-electron-volt – MeV

megarad – Mrad

megavolt – MV

megawatt – MW

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megohm – MΩ

meter – m

meter-kilogram-second ampere – mksa

meter-kilogram-second coulomb – mksc

meter of water equivalent – mwe, m (w.e.)

mho – ohm^{-1}

microampere – μA

microampere hour – μA h

microcoulomb – μC

microfarad – μF

microhm – μΩ

micrometer – μm

micromole – μmol

micron – μm

microns of mercury – μm Hg

microsecond – μs, μsec

microunit – μu

mil – spell out

mile – spell out

milliampere – mA

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millibarn – mb

millicurie – mCi

millidegrees Kelvin – mK

milligram – mg

millihenry – mH

milliliter – ml

millimeter – mm

millimeters of mercury – mm Hg

millimicron – mμm

milliunit – mu

millivolt – mV

minute – (i) min; (ii) ′ (unit of plane angle)

molal (concentration) – *m* (italic, closed up with preceding number)

molar (concentration) – *M* (italic, closed up with preceding number)

*mole – mol or spell out

mole percent – mol %, mole %

mole percent metal – MPM

month – spell out

nanobarn – nb

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nanometer – nm

nanosecond – ns, nsec

nanoseconds per meter – ns/m

neper – Np

neutrons per fission – n/[florin]

neutrons per second – n/s

neutrons per second per square cm – n/s cm^2

*newton – N

normal (concentration) – *N* (italic, closed up with preceding number)

oersted – Oe

*ohm – Ω

ohm centimeter – Ω cm

ohm centimeter per centimeter per cubic centimeter – Ω cm/(cm/cm^3)

ounce – oz

parsec – pc

parts per billion – ppb

parts per million – ppm

*pascal – Pa

picofarad – pF

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poise – P

pound – lb

pound-force per square inch – $lb/in.^2$

pounds per square inch – psi

pounds per square inch absolute – psi (absolute)

pounds per square inch gauge – psi (gauge)

rad – spell out

*radian – rad

radiation length – r.l.

reciprocal ohm (Ω^{-1}) – mho

revolutions per minute – rpm

revolutions per second – rev/s, rps

roentgen – R

rydberg – Ry (the rydberg is a unit of energy; if an energy constant is used, set as $\mathcal{R}$)

*second – (i) s, sec (either form must be used consistently throughout text); (ii) ″ (unit of plane angle)

shake – spell out

*siemens – S

standard cubic centimeter per second – sccm

statampere – spell out

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statohm – spell out

statvolt – spell out

*steradian – sr

stoke – S

tera-electron-volt – TeV

tetrahertz – Thz

*tesla – T

ton – spell out

torr – Torr, torr

townsend – Td

unified atomic mass unit – u

*volt – V

volume percent – vol %

*watt – W

*weber – Wb

webers per square meter – Wb/m^2

week – spell out

weight percent – wt %

Weisskopf unit – W.u.

year – yr