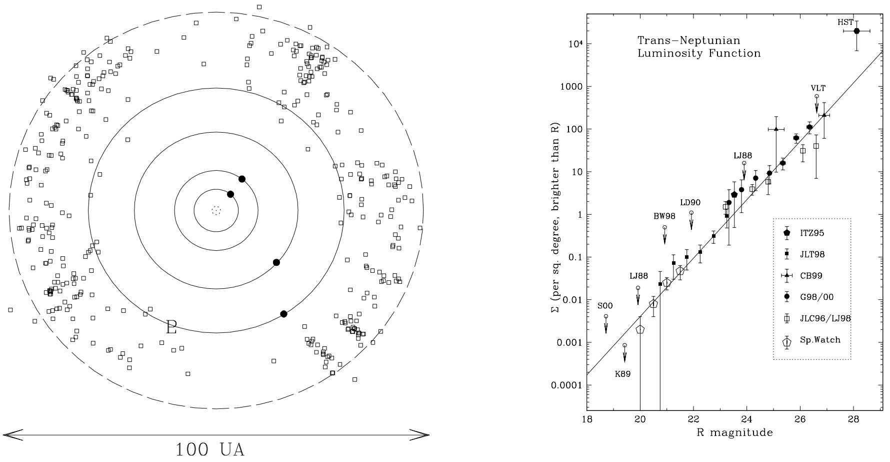

Left: the Kuiper Belt, as seen looking from the North Pole of our solar system. The 4 solid circles mark the orbits of Jupiter through Neptune, with their position in mid-1999 marked. The ‘P’ symbol marks the location of Pluto. The squares mark the positions of a sample of Kuiper Belt comets. Right: cumulative luminosity function of the Kuiper Belt. Symbols show several published surveys. The upper limits are 3-σ representations at the 50%-limit of the survey.

Edgeworth and Kuiper independently suggested the existence of a belt of material in orbits with semi-major axes between 30 and 50 AU, based on the observed distribution of short-period cometary orbits. Dynamical studies showed that after the giant planets reached their current masses the regions between them would be emptied of planetesimals on times scales much smaller than the age of the solar system. However, these studies also showed that outside of Neptune the hypothesised Edgeworth–Kuiper Belt (EKB) was stable, supporting modelling that the short-period comets come from this source via long-term gravitational instability. Today, more than 800 small bodies have been detected in the outer solar system, confirming that there is indeed an EKB. This belt has been found to be dynamically excited (random speeds much larger than would have allowed the accretion of these objects) and heavily depleted (much less material than would have allowed them to accrete).

Due to their large distance to the Sun and Earth, trans-Neptunian objects (TNOs) and Centaurs (objects with perihelia between the orbits of Jupiter and Neptune) are faint objects. Very few of them will be visible by Gaia: currently, only 65 objects are known to be brighter than magnitude 20 (the limit of completeness of Gaia) and 138 are brighter than magnitude 21 (10%-level of detection efficiency). Currently, we estimate to be about 75% complete for objects brighter than $m_R = 20$, and at least half complete for objects brighter than $m_R = 21$. So Gaia should detect a few tens of objects at most. Most of these should be Centaurs or Scattered Disk Objects (semi-major axis >50 AU and pericentre distance within gravitational reach of Neptune) on their way to the Centaurs region. Only a handful of Classical Kuiper Belt Objects (semi-major axis in the 30–50-AU range, low eccentricity, and low inclination) should be brighter than $m_R = 21$, and none should be brighter than $m_R = 20$.

Despite this small number, Gaia will provide a valuable contribution to the study of the outer solar system. First of all, it will be the first and only instrument that will survey the whole sky down to magnitude 20, allowing detection of any bright object of the solar system that is currently in front of the Milky Way, or at very high inclination. All ground-based observations have limited detection efficiency in the direction of the Milky Way because of stellar confusion. Starting or foreseen surveys should cover around 90% of the remaining sky. Existence or not of these bright objects will give fundamental clues on the formation mechanism of the EKB and the outer solar system.

For the largest Centaurs which will be cruising at 10 to 30 AU from Gaia, it should be possible to resolve them, providing the only direct measurement of the size of these objects, and hence of their albedo, besides Pluto. All other estimates of size and albedo rely on radio-photometry and thermal modelling.

Among the ~50 objects detected by Gaia, a handfull should be binaries. With the astrometric accuracy of Gaia, it will be possible to detect this binarity, and even to determine the orbit of the binary, providing a direct measurement of the mass of these objects. This sample will be a noticeable fraction of masses known at that time, allowing a decently accurate estimate of the volume bulk density.

Source: Jean-Marc Petit