Origin of Small Solar System Bodies with Hyperbolic Orbits

*Arika Higuchi[1], Eiichiro Kokubo[2]

1. RISE Project Office, National Astronomical Observatory of Japan, 2. Division of Theoretical Astronomy, National Astronomical Observatory of Japan

The interstellar space is filled with small bodies thrown out from the planetary system where they formed due to gravitational scattering by giant planets in the system. This idea was accepted before the recent discovery of 1I/2017 U1 (1I/'Oumuamua). 1I/2017 U1 (1I/'Oumuamua) is thought to be the first example of the interstellar object happened to be coming into the Solar System and observed. The Oort cloud, the long-period comet reservoir surrounding the Solar system, can also be a source of objects with hyperbolic orbits. A penetration of a star through the Oort cloud produces many hyperbolic comets and some of them could be observable from the Earth.
In this paper, we study the dynamical aspect of objects in hyperbolic orbits from the two different sources: interstellar and from the Oort cloud. We analytically derive the numbers of objects with given orbital element (eccentricity and perihelion distance) for each source. By comparing the numbers of the interstellar objects coming into the Solar system and the Oort cloud comets injected by passing stars, we can estimate which origin is more favorable for the object observed with the given v and b (i.e., e and q). For the orbital elements of 1I/2017 U1 (e ~ 1.19 and q ~ 0.25 au), we conclude that the possibility of having an interstellar origin is higher than that of an Oort cloud origin unless the Solar system had recently experienced close encounter with a star, which is unlikely.

Keywords: interstellar objects, Oort cloud, hyperbolic orbits

