Setting an observational upper limit to the number density of interstellar objects with Pan-STARRS

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Since the theory of a spherical reservoir of comets far beyond the planetary orbits (Oort, 1950) and subsequent work on origin and evolution of planets and small bodies (Charnoz and Morbidelli, 2003) it has been suggested that countless comets have left the Solar System shortly after its formation. Hence, it is likely that the other planetary systems ejected comets into interstellar space as well. However, the interstellar object (ISO) on a hyperbolic orbit with respect to the Sun has not been observed yet. In our work we derive the number density of ISO based on observational data from the Catalina Sky Survey (2005–2012) and Pan-STARRS1 survey (2010–2013). In the simulation we created 10,000,000 synthetic ISO based on velocity distribution by Grav et al. (2011) and used synthetics in the simulated survey study by using MOPS (Denneau et al., 2013). The number density of ISO was elaborated through the Poisson statistics of a non-detection with the 90 % confidence limit (C.L.) and detection efficiency of observed fields with known limiting magnitudes and survey characteristics. The number density was derived as a function of the absolute magnitude H and size-frequency distribution slope α by taking the cometary activity of long-period comets into account. We found that at 90 % C.L. the density of inert ISO population is 5.4×10^{-2} au^{-3} and 1.6×10^{-3} au^{-3} for the active population for objects larger than $H > 19$ and with $\alpha = 0.5$.

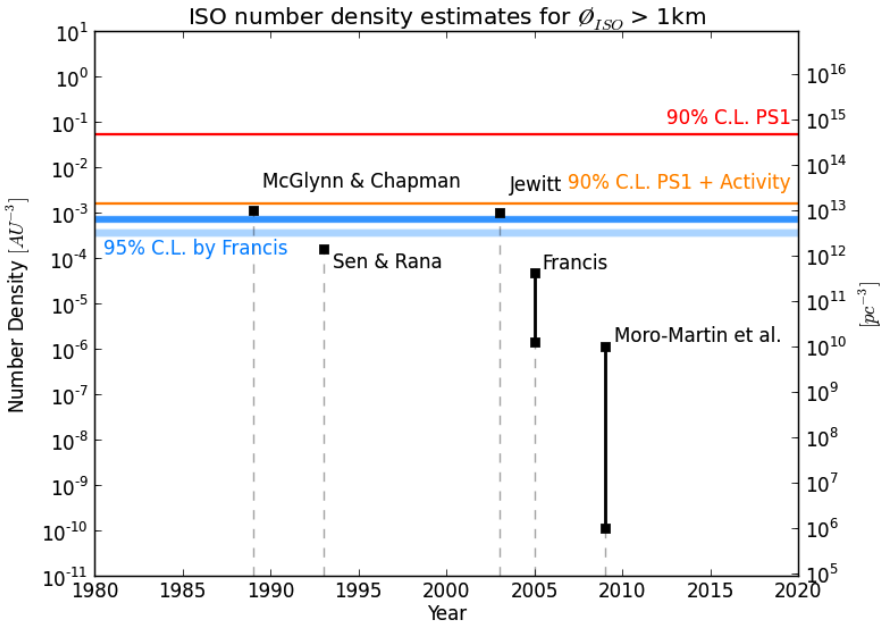

Figure: ISO number density limit set with Pan-STARRS1 in comparison to other estimates. It gives 90 % confidence limit with the size-frequency slope $\alpha = 0.5$ and $H > 19$. We derive the estimate for asteroid-like and cometary-like (active) objects.

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References: Charnoz, S. and Morbidelli, A. 2003, Icarus, 166, 141; Oort, J.J. 1950, Bull. Astron. Inst. Netherlands, 11, 91; Denneau, L. et al. 2013, PASP, 125, 357; Grav, T. et al. 2011, PASP, 123, 423.