ORIGIN OF METEORITES NEAR THE SUN.

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Introduction: The classical interpretation on the origin of meteorites is a catastrophic disruption event through a major collision of asteroids within the main belt that (together with nongravitational effects) delivered the meteoroids to resonances and then the Earth. But very short cosmic ray exposure (CRE) ages for some meteorites are inconsistent with their origin from catastrophic disruption within the main belt (e.g., [1]). This implies the origin of meteoroids as a free-floating body in the near-Earth region.

It is well known from dynamical studies that near-Earth objects evolve frequently to orbits with small perihelion distances [2-5]. It is estimated that up to 70 percent of near-Earth objects collide with the Sun during their orbital evolution [5]. Recently Granvik et al. [6] concluded that the deficit of near-Earth asteroids on orbits with small perihelion distances arises from the breakup of a substantial fraction of asteroids when they move near the Sun. Thus, disruption of bodies due to the strong solar tide, thermal stresses and interaction with the solar atmosphere at Sungrazing conditions may play a key role in the origin and modification of small near-Earth objects.

Model: In principle, meteorites provide unique possibilities for studies of dynamical aspects of near-Earth asteroids because orbital evolution considerations can be combined with estimates of CRE ages. But among objects with known CRE ages only a handful are appropriate because the accuracy of orbits is often insufficient even for qualitative studies of their long-term motion. We report here results of our dynamical studies of a few objects with measured CRE ages and relatively good orbits. We consider a large set of test orbits from the confidence region for each meteoroid. We use the symplectic integrator [7] to backward propagate the orbits taking account of perturbations from all planets. We estimate the fraction of particles reaching the near-Sun state (orbits with perihelion distances $q<0.1$ au) in the past. The probabilities of recent encounters with the Sun are different, but they are appreciable in all the cases and the times of these encounters are consistent with estimated CRE ages.

Chelyabinsk: 25 percent of test particles reach the near-Sun state in 2 Myr, and more than 50 percent of particles reach the near-Sun state in 5 Myr [8]. This is consistent with the estimates of CRE ages of 1.2-1.5 Myr [9-11].

Novato: This object has a well determined orbit thanks to observations of the CAMS system [12]. According to our integrations 36 percent of test particles reach the near-Sun state in 1 Myr, and 66 percent of particles reach the near-Sun state in 5 Myr. These data are consistent with the conclusion [13] that the change in shielding conditions of this meteoroid occurred during the last few Myr.

Almahata Sitta: This object has the most precise orbit among meteorites thanks to pre-atmospheric observations as a small asteroid. Six samples of the meteorite have an average CRE age of 19.2±3.3 Myr, but one sample has a lower CRE age of 11.0±1.4 Myr [14]. Our computations show that 25 percent of test particles reach the near-Sun state in 10 Myr, and 39 percent of particles reach the near-Sun state in 20 Myr.

Asteroid Itokawa: The CRE ages for Itokawa samples taken from the surface show a young age of 1.5±0.4 Myr [15], with an upper limit of approximately 8 Myr [16]. For this object, 3 percent of test particles reach the near-Sun state in 2 Myr, and 12 percent of particles reach the near-Sun state in 8 Myr.

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