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Dynamical features of Earth impactors

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Abstract

We describe our work to characterize the orbital and absolute magnitude distribution of Earth-impacting objects and to estimate the flux of impactors of various sizes.

1. Introduction

Estimates of the impact risk are usually based on dynamical and physical features of near-Earth objects (NEOs, small bodies moving in orbits with perihelion distances *q*<1.3 AU). At present about 10000 near-Earth asteroids have been observed as a result of a growing number of discoveries in recent years by dedicated survey programmes aimed at finding NEOs. In particular, the population of near-Earth asteroids with absolute magnitudes *H*<18 is thought to be fairly well constrained. However, smaller impactors can still cause very important damages and losses on the ground. For example, the 1908 Tunguska event is associated with an object as small as 30-50 m. The recent Chelyabinsk superbolide was caused by a body approximately 16 to 19 meters in size [1]. This implies that the terrestrial impact rate should be studied for such small objects too. In addition, the distribution of dynamical characteristics for impactors is different from estimates obtained from analysis of NEOs [2]. Therefore, we focus attention on objects that happen to pass very close to the Earth.

2. Absolute Magnitude Distribution of Hazardous Objects

At present, the number of such objects is large enough for statistical considerations. For instance, about 600 discovered objects passed within the Hill sphere (within 0.01 AU from the Earth). Objects that actually collide with the Earth, or pass very close, represent observational 'ground truth' so far as impact statistics are concerned. Moreover, the consideration of these objects has the advantage of constraining the flux of relatively small objects. We developed a special method that allowed us to estimate the absolute magnitude distribution of hazardous asteroids up to *H*=27. We adopted the standard form for the absolute magnitude distribution of $10^{\alpha H}$. We found that the distribution is well described with the slope α=0.28 for 16<*H*<21 and with the slope α=0.45 for 22<*H*<27. The *H* distribution density function has a striking decrease in the interval (21, 22) of *H*. Our model is consistent with approximately 20000 NEOs having diameters *D*>0.1 km estimated in [3] from the NEOWISE data.

3. Dynamical Characteristics of Impactors

In order to revise the actual impact hazard to the Earth, we numerically integrated orbits of each near-Earth asteroid for ±300 yr to see how many objects are likely to become impactors. We consider whether our estimates are consistent with impact rates determined by other methods. In our investigation, all potentially hazardous objects were assessed for impact probability. On this basis, we found the orbital distribution of objects passing close to the Earth. Our conclusion is that it is different from the distribution of the total population of NEOs. In particular, the estimated mean values of semimajor axes, eccentricities and inclinations of asteroids colliding with the Earth are much less than the corresponding values of NEOs. We study if there is any difference in the orbital distribution of large and small hazardous objects. We discuss also a cometary contribution to the terrestrial impact hazard. In particular, the features of the orbital and absolute magnitude distribution of cometary remnants and asteroids are compared.

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