MARS/MOON IMPACT RATE RATIO OF KILOMETER-SIZE IMPACTORS. Renu Malhotra[1] and Youngmin JeongAhn[2], [1]Lunar and Planetary Laboratory, The University of Arizona, Tucson, AZ 85721, renu@lpl.arizona.edu; [2]Institute of Astronomy, National Central University, Jhongli, Taiwan, jeongahn@gm.astro.ncu.edu.tw.

Introduction: The Mars/Moon ratio of the rate of asteroidal-cometary impacts is a fundamental parameter in the impact crater based chronology of Mars over geological timescales. This ratio is estimated by computing the collision probabilities of potential impactors in the inner solar system, and it depends upon our knowledge of the orbital and size distribution of the population of Mars-crossing and Earth-crossing minor planets. A review of the literature finds somewhat inconsistent values reported for the present-day Mars/Moon impact rate ratio: 4.8—4.93 [1,2] and 3.2 [3,4]. Here we report a resolution of this discrepancy.

An examination of the up-to-date observational data of the orbital and absolute magnitude distribution of minor planets shows some features that have been overlooked in previous studies. First, we note that the shape of the distribution function of the absolute magnitude, *H* (which serves as a proxy for the size-frequency distribution), of Mars-crossers is noticeably different from that of the Earth-crossing population of near-Earth objects. (Some previous studies have assumed that the shape of the size-frequency distribution of near-Earth objects is the same as that of the Mars-crossing objects.) We also notice a difference in the *H* distribution of high inclination and low inclination Mars-crossers ($i < 15$ degrees or $i > 15$ degrees). Secondly, the perihelion longitudes of the Mars-crossers are not randomly distributed (as assumed in previous studies). Rather, there is a preferred orientation of the longitude of perihelion; moreover, the peak direction and the degree of their concentration about the peak direction is correlated with orbital inclinations. This non-randomness is owed to secular planetary perturbations that give rise to a forced eccentricity vector component whose magnitude and direction depend upon both the orbital semimajor axis and inclination of an individual minor planet. For most minor planets, the forced eccentricities are modest compared to their free eccentricities. However, in the population of Mars-crossers, the forced component is sufficiently large that it produces a high degree of concentration of the longitudes of perihelion. The peak perihelion direction and its degree of concentration are different for the low and high inclination populations of Mars-crossers. Thirdly, Mars itself is subject to strong secular perturbations. At the present epoch, its perihelion direction nearly coincides with the peak direction of the low inclination Mars-crossers. These properties of the Mars' impactor population significantly affect the collision probabilities as well as the distribution of their impact velocities with that planet.

We modified the method of Opik [5] and Wetherill [6] to take account of the non-uniform distribution of the perihelion longitudes, in order to compute more accurately the collision probabilities and impact rates on Mars. We account in detail for gravitational focussing effects, as these are also affected by the non-random distribution of perihelia because the encounter velocities of Mars-crossers are correlated with their perihelia. We also computed updated estimates of the impact rate on the Moon by the Earth-crossing population of near-Earth objects which also exhibit a non-uniform distribution of the argument of perihelion [7].

Results: The Earth-crossing population of minor planets is observationally complete down to H<18 (total observed number 516). For this population, we find the impact rate on the Moon to be $1.9\text{x}10^{-15}$ km^{-2} yr^{-1}.

For the observationally nearly complete set of Mars-crossers, i.e., those having H<16 (observed population of 1322, and we account for an estimated completeness factor of 80%), we find that the mean impact flux on Mars is $9.2\text{x}10^{-16}$ km^{-2} yr^{-1}. It is noteworthy that if we were to assume a uniform random distribution of the perihelion longitudes of Mars-crossers, the impact flux would be about two times higher.

To compute the impact flux on Mars of kilometer-size impactors, i.e. H<18, we extrapolate the Mars-crossing population from H<16 to H<18 by using a multiplication factor N(<18)/N(<16); we compute the latter by using a smooth extrapolation to H<18 of the observed H-distribution function N(<H) which is well-defined over the range 13<H<15. We find the estimated mean impact flux on Mars of the H<18 Mars-crossers is $9.5\text{x}10^{-15}$ km^{-2} yr^{-1}. This gives a Mars/Moon impact ratio of kilometer-size impactors of 5.0.

Alternatively, we can assume that the shape of the H distribution of Mars-crossers is the same as that of the better-known Earth-crossers, and scale it to the observationally complete population N(H<15) of Mars-crossers. This yields a smaller impact flux of kilometer-size impactors on Mars, $5.7\text{x}10^{-15}$ km^{-2} yr^{-1}, and a smaller Mars/Moon impact ratio of 3.0.

The higher value of 5.0 of the Mars/Moon impact ratio obtained above is similar to the results of Ivanov [1,2], even though our estimate is based on an updated dataset which has a larger population of Mars-crossers. This is because there is a fortuitous near-cancellation of the effect of the larger impactor population and the lower average collision probability due to the non-uniform distribution of the perihelion longitudes.

The lower value of 3.0 of the Mars/Moon impact ratio is obtained in the alternative model, and is similar to the results of Le Feuvre & Wieczorek [3,4]. The main reason for this lower value is that scaling the near-Earth objects to Mars-crossers results in a lower population estimate of the latter.

In summary, the range 3.0-5.0 of the Mars/Moon impact rate ratio expresses the underlying uncertainty in our current knowledge of the $H<18$ ~kilometer-sized Mars-crossing impactor population. A detailed description of this work is given in [8].

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