WHEN WORLDS COLLIDE: WITNESSING PLANETARY-SCALE IMPACTS IN THE COMING DECADES. J. R. Masiero[1], J. M. Bauer[1], T. Grav[2], and A. K. Mainzer[1]. [1]NASA Jet Propulsion Laboratory, California Institute of Technology (*joseph.masiero@jpl.nasa.gov*), [2]Planetary Science Institute.

The history of the inner Solar System is a record of cataclysmic impacts that restructured the population of bodies there in myriad ways. Collisions in the early Solar System fed the growth of the terrestrial planets, resulting in the formation of the Earth-Moon system [9]. Later pulses of impacting material formed giant craters on the Moon and implanted organics and volatile on the Earth [8]. Impacts between asteroids over the last few billion years have resulted in massive craters or compete disruption of the target body, as seen on Vesta by the *Dawn* spacecraft [13] and in the Main Belt as over 100 identified asteroid families [10]. Recently, we have witnessed apparently-asteroidal objects in the Main Belt become suddenly active as they undergo disruptive events (e.g. 2010 A2 [1]).

Disruptive impact events like this occur on a scale that cannot be simulated in any laboratory. Impact velocities are tens of kilometers per second, and released energies are far in excess of any that humankind has produced (e.g. the small Chelyabinsk 18-meter impactor released as much energy as a moderately-sized nuclear weapon [12]). Numerical simulations have allowed us to model these events, and comparisons can be drawn to the observed end-states such as family size distributions or shocks recorded in minerals [3], but there is little data probing the impact process itself. Understanding the effects of these impacts is a critical component to our models of the formation of planetary systems (both ours and those around other stars), the current interior of small asteroids, the composition of the zodiacal dust cloud, and the evolution of life of Earth.

Present-day asteroid surveys are witnessing impact-induced activity once every few years [2]. In the coming decade, new surveys such as LSST [4] and the proposed NEOCam space telescope [5] will increase our catalog of known Main Belt objects by an order of magnitude, up to ~10 million objects. This will increase the rate at which impact events are discovered, but also will provide us the tools needed to *predict* a catastrophic impact before it happens. As with potential Earth-impacting asteroids that are currently being tracked by NASA's Planetary Defense Coordination Office (e.g. *http://neo.jpl.nasa.gov*), surveys will produce probabilities for impacts between Main Belt asteroids that will require organized followup efforts to confirm. However, the low chances of impact between two asteroids will be partially offset by the large number of potential impact targets being tracked. Impact probability is also enhanced by the existence of families formed by previous impacts: these objects have similar orbital elements, and thus will have a higher likelihood of impacting each other than would be expected from a randomly distributed population of objects.

Based on estimates of the formation rate of craters larger than 1 km on Vesta [11] (that is, formed by impactors D>100 m) and observed size distribution of MBAs [6], we estimate that a collision between two objects recorded in the catalogs that will soon be available from next-gen surveys has an occurrence rate of ~0.005 per year, even before accounting for amplification due to collisions among family members on similar orbits. Thus there is a non-negligible chance that a predictable collision will occur within the 2050 timeframe. Any future surveys to fainter brightness limits will only increase this probability.

With a few years of advance notice of a collision within the Main Belt, coordinated observing campaigns could be organized to characterize the bodies before, during, and after the collision (similar to the characterization effort during the Deep Impact mission [7]). However, the ideal case would be one where an impact could be predicted with one or two decades of advance notice. Is this case, reconnaissance spacecraft could be sent to study the impact *in situ*, similar to the flyby campaign of 1P/Halley, with staggered arrival times to ensure all phases of the impact event are observed.

Certain determination of an impact between two asteroids requires a knowledge of their orbits significantly more accurate than what is available today for the majority of objects. However, near-future surveys promise a rapid growth in the data sets used to determine orbits, while near-future telescopes like JWST and TMT will be able to provide accurate astrometric measurements with precision far surpassing the current generation of telescopes. Likewise, reconnaissance spacecraft would need a standard set of instruments common to *in situ* exploration today (e.g. imager, VNIR spectrograph, dust flux counter, etc.). Thus, there are no significant technological or conceptual hurdles that would impede an investigation of this type in the 2050 time frame. Continued survey (as part of ongoing Planetary Defense activity) and regular orbital monitoring will be sufficient to enable this opportunity to study the largest impacts in the Solar System.

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