# Lightcurve signatures for non-catastrophic asteroid collisions

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Current all-sky surveys such as Pan-STARRS 1 and the Catalina Sky Survey are now discovering objects with orbits similar to main-belt asteroids but surrounded by extended material. Some may represent catastrophic collisions resulting in significant disruption of the target asteroids (Snodgrass et al. 2010, Jewitt et al. 2010, Stevenson and Jewitt 2012, Moreno et al. 2012). The 2010 event at asteroid (596) Scheila is accepted as being due to the impact of a small asteroid on a larger body, resulting in a non-catastrophic cratering event (Jewitt et al. 2011, Ishiguro et al. 2011, Hsieh et al. 2012). Given a nominal size distribution, small collisions should dominate the catastrophic impact rate (Bottke et al. 2005, Denneau et al. 2014). A search for such events has been reported by Cikota et al. (2014). We have performed a series of analytical calculations to model the psf brightness increase resulting from a sub-catastrophic collision onto a main-belt asteroid. We used the cratering scaling laws as derived by Holsapple and Housen (2012) combined with a range of strength and other physical parameters as indicated by observation and laboratory experiments. Target radii from 1 km to 100 km represented the known main-asteroid-belt population, and impactor sizes from 1 m to 100 m ensured we are in the non-catastrophic regime. At present, we include realistic debris size and velocity distributions, together with gravitational fallback onto the target asteroid, but not radiation pressure on the grains. We find a C-type impactor radius of $\simeq$ 25 m produces results consistent with the reported observations for (596) Scheila. In terms of general impacts, we find that almost all collisions involving an impactor with radius $r \geq$ 10m would result in a brightness increase of $\geq$ 1 magnitude visible 24 hours after the collision. However a combination of debris fallback and expansion of debris beyond the seeing disk rapidly reduces the photometric signature. Within 1 week of a collision, 100-m impacts on $r > 30$ km asteroids may only be detectable by observation of the resolved ejecta cloud around the body. Conversely, 10-m impactors on $r \simeq 10$ km asteroids would be easily detectable by current surveys one month after the collision.

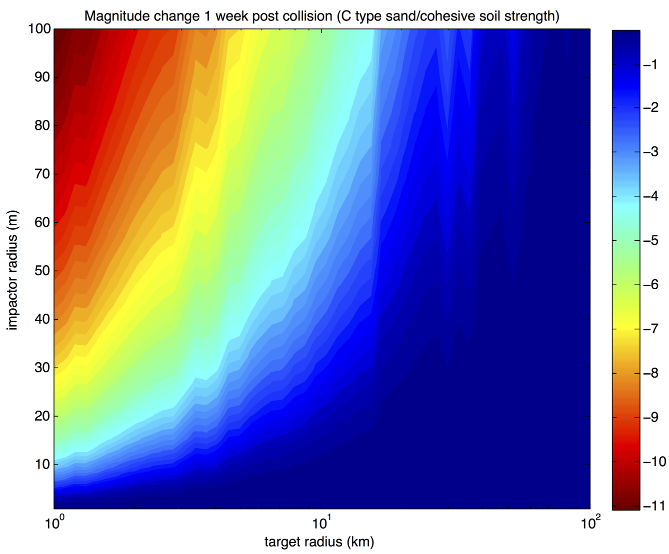


**Figure:** Predicted magnitude increase within 2 arcsec of a target C-type asteroid in the outer main belt, 7 days after impact by a C-type impactor.

**Acknowledgements:** EM acknowledges support from QUB. AF acknowledges support from STFC.

**References:** W. Bottke et al. Icarus, 175, 111 (2005); S. Cikota et al. Astron. Astrophys., 562, A94 (2014); L. Denneau et al. Icarus, submitted (2014); K.A. Holsapple and K.R. Housen. Icarus, 221, 875 (2012); H. Hsieh et al. Astrophys J., 744, 9 (2012); M. Ishiguro et al. Astrophys J. Lett., 741, L24 (2011); D. Jewitt et al. Nature 467, 817 (2010); D. Jewitt et al. Astrophys J. Lett., 733, L4 (2011); F. Moreno et al. Astrophys J. Lett., 761, L2 (2012); C. Snodgrass et al. Nature 467, 814 (2010); R. Stevenson and D. Jewitt. Astrophys J., 759, 142 (2012).