A COMPUTATIONAL APPROACH TO MODELLING THE DART IMPACT. S. Braroo[1] and K.T. Ramesh[2], [1]Mechanical Engineering, Johns Hopkins University, G-45, Malone Hall, 3400 N. Charles St. Baltimore, MD 21218, 217-417-3802, sbraroo1@jhu.edu, [2]Johns Hopkins University, 141, Malone Hall, 3400 N. Charles St. Baltimore, MD 21218, 410-516-7735, ramesh@jhu.edu.

Introduction: Impact plays a leading role in the formation of planetary bodies within and beyond the solar system. In addition, there have been recent efforts to formulate mitigation strategies to prepare for the possibility of asteroid impact on the earth. Kinetic impact is one of the many potential deflection strategies under consideration for near-earth asteroids (NEAs). Due to scale limitations of laboratory experiments, computational modelling of impact can deepen our understanding of the history of formation and composition of these bodies and can help us design successful deflection strategies for potentially hazardous NEAs.

The predictive success of the computational modelling effort is predicated on making reasonable assumptions for the surface and sub-surface properties of the asteroid as well as capturing the physics of the impact event as accurately as possible. We aim to capture the underlying mechanisms and pre-existing microstructure as well as their evolution during and after the impact. Towards this end we have performed simulations of hypervelocity impact at 6 km/s onto Didymoon, the secondary member of the Didymos (65803) binary system. This deflection experiment is set to occur in October 2022 as part of NASA double asteroid redirection test (DART) mission.

For our simulations, we use the Tonge-Ramesh material model (TR model) for geomaterials [1] incorporated within the Material Point Method (MPM) Uintah computational framework. The TR model is a micromechanics based constitutive model for high-strain rate failure of geo-materials that accounts for the micromechanics of dynamic fracture within materials containing flaw distributions, with explicit accounting for varying crack speeds and massive crack interactions. The model has been recently used in asteroid-scale impact simulations [2]. In conjunction with the MPM framework it allows us to make physically-based predictions for the behavior of the asteroid including the residual damage distributions, the ejecta velocity distributions and the momentum transfer. In addition, it enables a natural hand-off to N-body code gravity calculations.

Preliminary results from our simulations show damage accruing along the impact axis at both ends (Figure 1). A metric for damage estimation, based on a volume average of the crack sizes, is tracked as initial cracks grow upon impact. At a threshold value of 0.2 (as indicated by red in Figure 1), fragmentation begins. We also report a momentum enhancement factor of approximately 1.2 based on our current modelling effort and definition of ejecta.
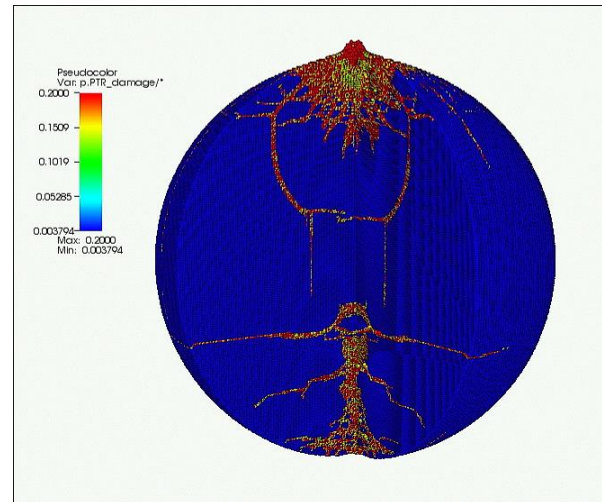

Figure 1: A cut-section through Didymoon at 200ms of simulated time after impact (impactor contacts Didymoon at the north pole). PTR_damage value of 0.2 (red) represents fragmented material where as dark blue represent undamaged material. Damage is seen to accrue at both poles.

References: [1] Tonge, A.L., Ramesh, K.T., Barnouin, O. (2016) *Icarus, 266,* 76-87. [2] El Mir, C., Ramesh, K.T., Richardson D.C. (2019) *Icarus, 321,* 1013-1025

Additional Information: The material and some of the text in this abstract is related to work presented at a poster in AGU 100 and also to work that may be presented the Planetary Defense Conference and the Mach conference.