Physical properties of Taurid meteoroids of various sizes

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The origin and history of the Taurid meteoroid complex is still debated. Short period comet 2P/Encke is considered the parent body but the orbits of some asteroids match the orbits of Taurid meteors better. Physical studies of Taurid meteoroids are complicated by the fact that this low activity shower is contaminated by interlopers with similar orbits but different origin. Spurný et al. (2017) identified a well-defined orbital structure, which is responsible for the enhanced Taurid activity in some years and is in the 7:2 resonance with Jupiter, as proposed earlier by Asher & Clube (1993). Asteroids of sizes of several hundred meters were found within this structure called the Taurid new branch. Physical properties of the observed Taurid meteoroids were evaluated using the PE criterion of Ceplecha & McCrosky (1976). It was found that Taurids cover all types from I to IIIB, with small meteoroids being of predominantly of type II and some of them of the strongest type I, while meteoroids larger than ~0.1 kg being of type IIIA and the largest ones even of type IIIB.

To understand this behavior, we modeled atmospheric fragmentation of 16 well observed Taurids, 15 of them members of the new branch, with detailed radiometric light curves (5000 samples per second) available. The erosion model of Borovička et al. (2013) was used. The meteoroid masses ranged from less than 10 g to almost 1000 kg. The Taurids were characterized by the presence of either short flares (modeled as immediate dust release) or longer periods of enhanced brightness (modeled as eroding fragments loosing dust more gradually). Only seldom, a disruption into large numbers of similarly sized fragments was needed to explain the light curve. The dynamic pressures at the fragmentation points were evaluated together with the amount of lost mass. The brightness before the start of fragmentation, together with the observed deceleration, was used to estimate the bulk density of meteoroids.

The Taurid material was found to be highly heterogeneous with large meteoroids being generally more fragile but containing some stronger parts. The inferred bulk densities ranged from 200 to 2000 kg/m^3. The fragmentation behavior varied from case to case. A common characteristic was the value of the dynamic pressure, p_10%, at which the mass of the largest surviving fragment decreased below 10% of the initial mass. For eight meteoroids this pressure was in a narrow range between 0.04 and 0.06 MPa. In cases of four small meteoroids (all with initial masses below 0.02 kg), p_10% was larger than 0.08 MPa, but in only two cases it exceeded 0.1 MPa. On the contrary, p_10% was 0.01 MPa or less for two meteoroids larger than 1 kg.

The largest fragment with strength exceeding 0.1 MPa had a mass of 0.5 kg and was originally part of a 30 kg meteoroid. It was, nevertheless, destroyed already at 0.16 MPa. The strongest fragment was a 3 g part of a 16 g meteoroid (producing type I fireball), which survived until a disruption at 0.4 MPa. Our data suggest that it is unlikely for Taurids to produce sizeable (> 10 g) meteorites on ground.