

Small Geminids are more fragile than large ones

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Motivation

- detailed fragmentation modeling yields physical and mechanical properties of a meteoroid
- ...and also its parent comet/asteroid for shower meteors with a known parent body
- what is the nature of the Geminids material?
- can we confirm the observed trends for meteoroids with smaller initial mass?

Geminids modeling

- we modeled 14 Geminids and 9 asteroidal fireballs of comparable entry mass
- data from the European Fireball Network (we fitted radiometric and photometric light curves, foremost fragment dynamics)
- two-station videodata from MAIA (Koten et al. 2011) EMP 108 and narrow-field-of-view camera

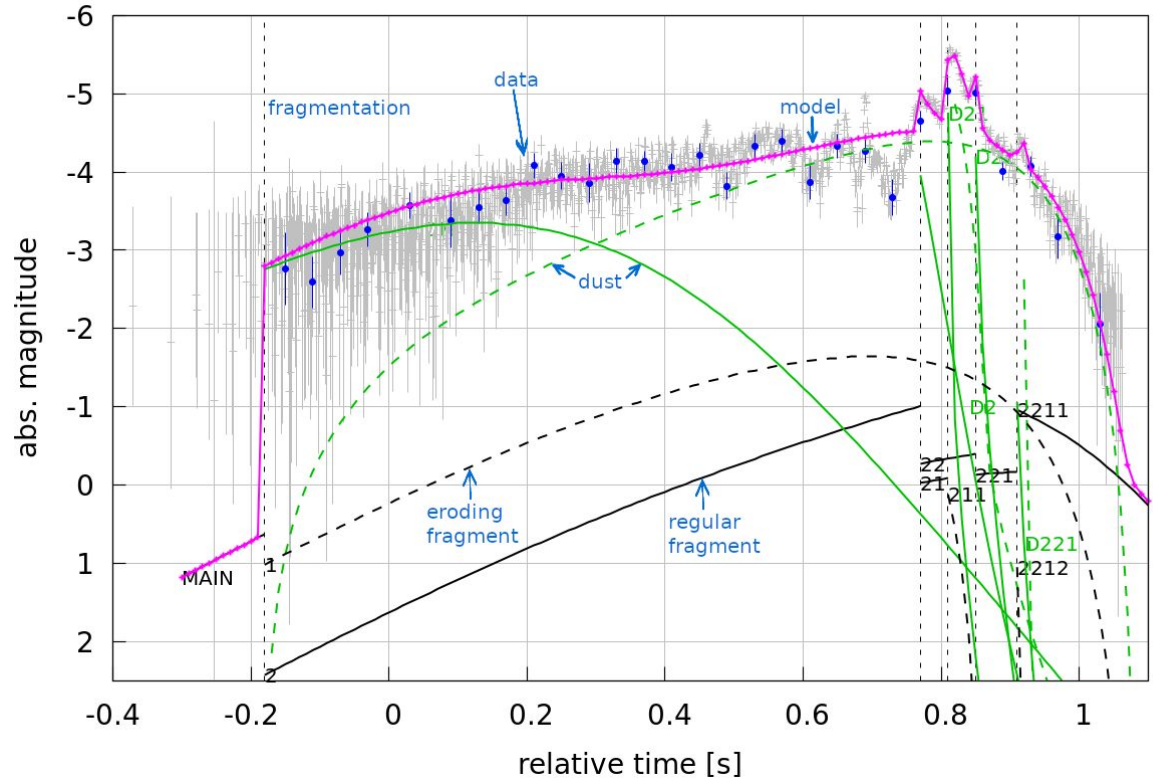
Geminids modeling

- semiempirical fragmentation model of Borovička et al. (2020) *AJ* 160 connected with a genetic algorithm optimizer (Henych et al. 2023) *A&A* 671
- meteoroid fragmentation times visible in the radiometric LC
- dust grains released immediately upon fragmentation or gradually via erosion of fragments

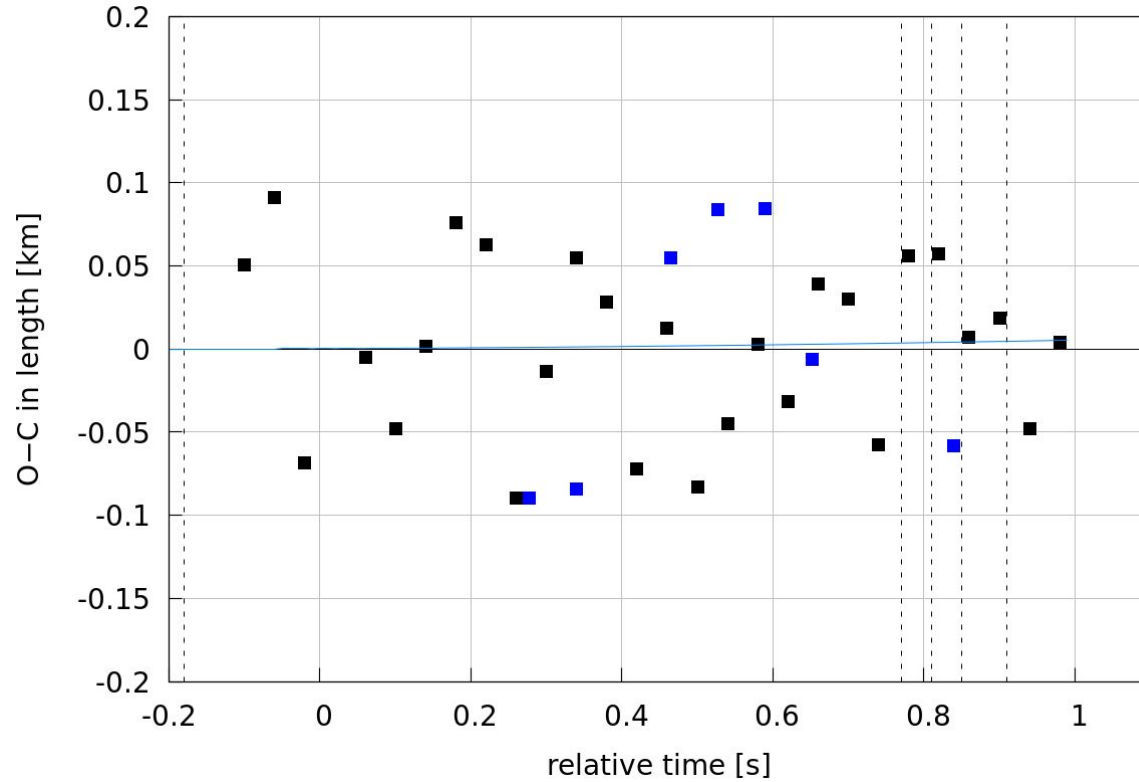
Geminids modeling

- optimized: initial mass, velocity, height, exact fragmentation times, # of fragments, fragment masses, dust & eroding grains properties, ...
- fixed: ablation, drag & shape coeffs., bulk density, $\tau(m,v)$
- we derived dynamic pressure exerted on the meteoroid and its fragments
- at fragmentation points it serves as a proxy for a tensile strength of the fragmenting meteoroid

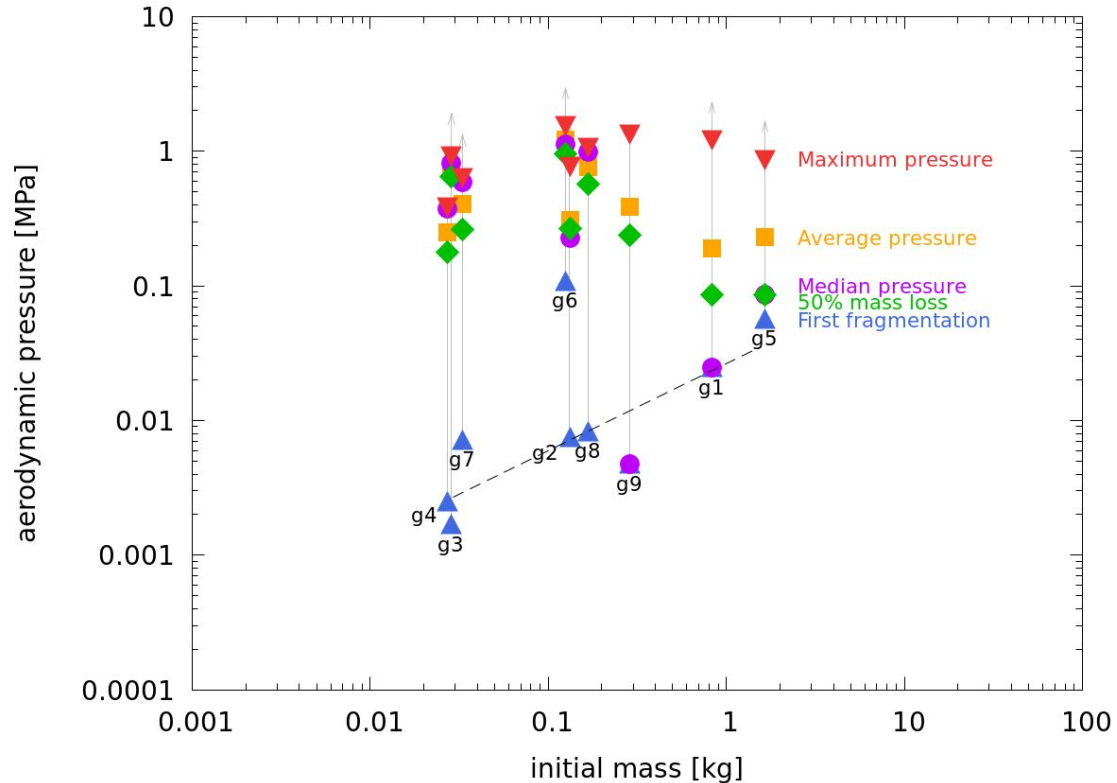
Radiometric & photometric data



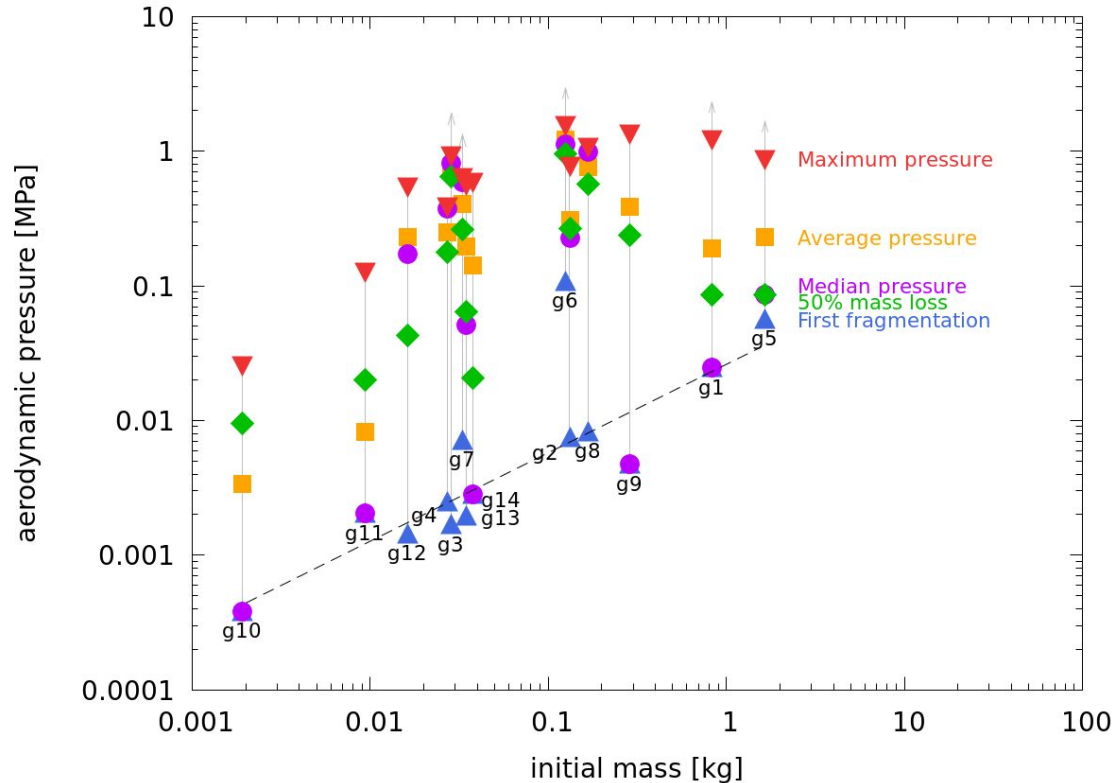
Dynamics



Pressure statistics in Geminids



Pressure statistics in Geminids



Published results: Geminid fireballs

- formed by compact and coherent carbonaceous material
- smaller Geminids fragment at lower pressures than larger ones => thermal stresses destroy larger and weaker meteoroids (Čapek & Vokrouhlický 2012)
- large Na variation seen in mm-sized Geminids but not in cm-sized Geminids
- all results in Henych et al. (2024) A&A 683

Luminous efficiency

- had to use two different luminous efficiency functions
 1. Pecina & Ceplecha (1983) BAIC 34 for small Geminids
 2. ReVelle & Ceplecha (2001) ESA SP495 modified by Borovička et al. (2020) AJ 160 for larger ones
- there is likely a transition between the two functions for 10–100 g meteoroids

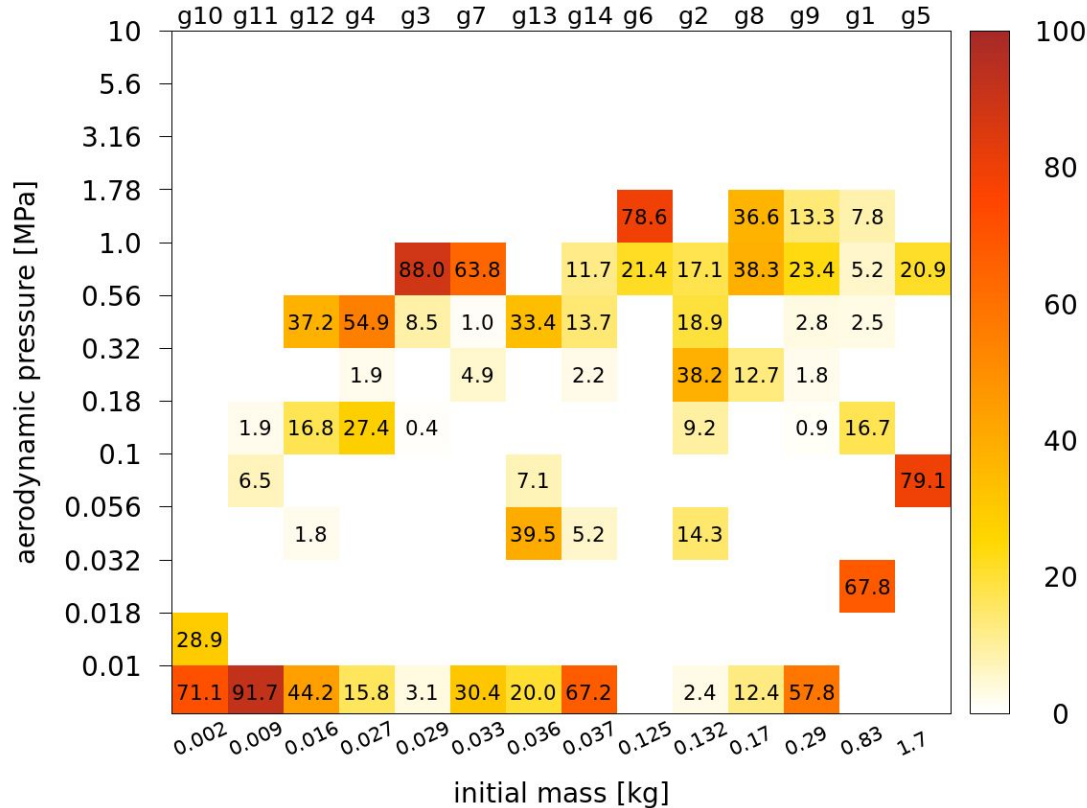
Mechanical vs. thermal fragmentation

- we model fragmentation for even smaller meteoroids observed by intensified video technique
- erosion model of Borovička et al. (2007) *A&A* 473
- if enough data, we aim to describe the transition between thermal erosion and mechanical fragmentation
- mechanical forces are important in transition flow and continuum flow
- we need to calculate the height of the transition / continuum flow for each Geminid (Silber et al. 2018) *ASR62*

Take away messages

- we use semiautomatic modeling of fireball fragmentation to derive the physical properties of meteoroids of some major showers
- small Geminids start to crumble at systematically lower pressures than large Geminids (2 g – 1.7 kg)
- thermal stresses destroy larger and weaker meteoroids

Strength proxy distribution in Geminids



Spectra of Geminids

