

□ **NEO Characterization**

**RAINING FIRE: METEOROID CHARACTERISATION BASED ON BALLISTIC
TRAJECTORY ANALYSIS**

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Meteoroids are the solid remnants of asteroids and comets, ranging from micrometres to decametres in size. Upon entering Earth's atmosphere, they follow a ballistic trajectory that is partly determined by their composition and internal structure. They display a variety of behaviours including harmless disintegration, meteorite deposition (e.g: [Ngweba](#)), explosive airbursts (e.g: [Chelyabinsk](#)), or even cratering. Understanding the spatial and temporal distribution of meteoroid falls, as well as their potential consequences, is a matter of global safety and security. Unfortunately, compositional and structural information is difficult to gather without physically collecting fallen meteorites, which represent only the toughest fraction of extraterrestrial intruders. This study proposes novel methods to characterise *all* the material that enters our atmosphere, whether it can be collected or not.

Falling meteoroids ignite and radiate visible light in response to intense ram pressure, rendering them visible to ground-based fireball camera networks across the globe. These networks include the Global Meteor Network (GMN), the European Fireball Network (EFN), and Australia's Desert Fireball Network (DFN). When multiple cameras within the same network capture the same burning meteoroid, they can precisely calculate its 3D trajectory and several useful dimensionless parameters. The first is the *ballistic coefficient* (α), which compares the drag and weight forces upon a falling object. High- α objects are more susceptible to atmospheric deceleration than low- α objects. The second parameter is the *mass loss factor* (β), which indicates the ease of removing material from a falling meteoroid. High- β objects tend to burn rapidly and are unlikely to survive long enough to deposit fragments upon the ground. As demonstrated by [Gritsevich \(2009\)](#) and [Sansom et al \(2019\)](#), α and β can be determined using only altitude and velocity data, with no required assumptions. The final parameter of interest is the *pressure factor* (P_f) value formulated by [Borovička et al \(2022\)](#). It depends on estimates of entry mass and maximum ram pressure, and indicates bulk strength. Stony and metallic asteroids produce higher P_f values than icy cometary bodies, for example.

Plotting α , β and P_f values for various falls can enable reasonable estimates of bulk composition and strength of the fallen objects. Subsequently, details of internal structure can be inferred, such as the presence or absence of melt veins, cementing min-

erals or large pores. We perform a quantitative study of ~150 instrumentally observed falls, including almost 60 meteorites, and dozens of Geminid meteors that originated from 3200 Phaethon. We also examine thousands of simulated meteoroids to investigate links between α , β , composition, structure, and dynamic behaviour. This presentation will summarise preliminary results, with a focus on the compositional and structural features that contribute to hazardous impacts. We will also consider the potential for comprehensive characterisation of all extraterrestrial material that rains upon Earth.

Comments:

Oral presentation preferred :)

We delivered a similar presentation at the 2024 Australian Space Research Conference. By the time of the 2025 PDC we expect to have more data and fresh findings to share.