Birth and destruction in protoplanetary disks: dust production by planetesimal collisions

Diego Turrini (INAF)
Lia Marta Bernabò, Leonardo Testi, Francesco Marzari, Danae Polychroni

Dust plays a central role in the chemical evolution of protoplanetary disks and is the source material from which planetary bodies form. Coagulation into planetesimals and planets is expected to steadily decrease the dust abundance in disks over time. However, recent surveys point to the median dust content of disks increasing from 1 to 2 Myr in nearby star-forming regions. Furthermore, resolved observations of HD 163296 reveal unexpected regions of high dust concentration across its extension. Building on our insight on the collisional evolution of small bodies from the Solar System, we show that such unexpected behaviours of the dust stem from the planet formation process. The early formation of massive planets dynamically stirs the nearby planetesimals and causes high-velocity impacts between them, resulting in the production of second-generation dust. This collisional production naturally explains the rise in the dust population observed in disks with ages between 1 and 2 Myr, suggesting this is the characteristic timescale of giant planet formation. The appearance of second-generation dust also explains the spatial distribution of dust observed in older disks like HD 163296. By sustaining the dust population over time, this collisional rejuvenation process acts to extend the duration of the planet formation process and the chemical evolution of disks.