Contribution ID: **118** Type: **Contributed talk**

Turbulent processing of polycyclic aromatic hydrocarbons (PAHs) in protoplanetary discs

Monday, 15 May 2023 15:45 (15 minutes)

The infrared signals of polycyclic aromatic hydrocarbons (PAHs) have been detected in numerous circumstellar discs. PAHs contribute to the heating of the disc's photosphere through efficient UV absorption and are crucial for disc evaporation models. Despite a correlation between effective stellar temperature and low PAH detection rates, the diversity of PAH detections at similar stellar properties is not well understood. In the era of the James Webb Space Telescope (JWST), the infrared spectrum is becoming more accessible than ever.

To explain this diversity in observations, we propose the formation of PAH clusters, the adsorption of PAHs and PAH clusters on dust grains, and their reverse-processes as key mechanisms in protoplanetary discs. Driven by vertical turbulence, these processes happen on cycles throughout the lifetime of a disc.

We developed a theoretical model to estimate the relevance and timescale of these processes in a Herbig Ae/Be disc environment and calculated the gas-phase depletion of PAHs. Our results show that the clustering of gas-phase PAHs is very efficient which prevents them from evaporating off the grains even in UV-rich environments. Evaluated over the lifetime of protoplanetary discs ($1 - 10$ Myr), we find a depletion of PAHs by a factor that ranges between 50 and 1000 compared to the standard interstellar medium (ISM) abundance in the inner disc. Through these processes, we favour small PAHs ($\leq$ 60 C atoms) as the major gas-phase emitters of the disc's photosphere as larger PAHs remain on the grain surface.

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Session Classification: Parallel session

Track Classification: NOVA NW2