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Binding environments of precursors to complex organic molecules in protoplanetary disks: a computational study

Aneesa Ahmad

The presence of complex organic molecules (in the form of gas-phase methanol) in protoplanetary disks have finally been revealed around young stars in observations with ALMA (the Atacama Large Millimeter/submillimeter Array); methanol is found to be rotationally cold and likely arising from non-thermal desorption from the cold icy reservoir in the disk midplane. The confirmation of methanol in protoplanetary disks has revealed the presence of a complex organic ice reservoir in disk midplanes for the first time. This reservoir may be processed to form molecules of higher complexity, the rates of which depend on the binding energies and binding environments of key radicals under the conditions in disk midplanes. We have modelled amorphous solid water and methanol ices, as well as mixed water-methanol ices at several temperatures; 10K, 20K, 50K, and 70K, yielding a range a range of interstellar ices, from which we have extracted amorphous clusters. In this research talk, we explain the motivation behind this work, and show the results of some simulations of the binding of methanol, water and their associated radicals with our interstellar ice clusters. This research has been carried out using molecular dynamics simulations performed using the GROMACS software package, DFT calculations were performed using the Gaussian16 software package and binding energies were computed using the binding energy evaluation platform (BEEP) at the mpwb1k-d3bj_def2-tzvp level of theory.

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A trail of dust from a young embedded brown dwarf in the outskirts of the Orion Nebular Cluster

Thomas Haworth

JWST NIRCam has revealed an embedded brown dwarf that is associated with an extremely long, narrow dark trail in the outskirts of the Orion Nebula. A very strong sensitivity of the scattering opacity to maximum grain size at JWST wavelengths means that this dark trail can be explained purely in terms of a maximum grain size enhancement in the dust. However, the question remains what gives rise to the trail of larger dust. We explore various possibilities, with the two most promising being mass loss of circum-brown-dwarf material by a weak external photoevaporative wind or a Bondi-Hoyle-Lyttleton accretion wake.

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North PHASE observation of the young cluster Tr37

Ferdinand Hollauf

The North-PHASE Legacy Survey is using the T80 telescope from the Javalambre Observatory (Spain) to study variability in several young clusters in the northern hemisphere. It produces time-resolved observations that enable us to 'use time to map space', identifying young variable stars and the processes that cause their variability, such as stellar spots, accretion variations, and occultations by circumstellar material. I will present the initial results for the cluster Tr37, which will be the subject of my PhD, having started in January 2024.

Understanding CO Depletion in Wind-Driven Protoplanetary Discs

Zuzanna Jonczyk

Recent ALMA observations have revealed a significant decrease in the gas-phase CO abundance within protoplanetary discs, with CO abundances depleted by up to two orders of magnitude relative to the interstellar medium. One plausible explanation for this depletion is CO sequestration in ice on the surfaces of large grains. An essential ingredient of this mechanism is the diffusion of CO from the upper layers of the disc to the midplane, where temperatures are low enough for CO to freeze out. The efficiency of CO sequestration is therefore sensitive to the strength of turbulence in the disc, requiring turbulent alpha parameters of around 10^-3 to produce sufficient depletion on Myr timescales. However, ALMA has revealed that mm-sized grains form thin dust layers in protoplanetary disc mid-planes, indicating that turbulence may be much weaker than this. MHD winds are therefore currently considered important in the outer regions of protoplanetary discs, and their effects on disc composition are yet to be understood. I will present the results of new work investigating the impact of MHD-driven winds on the depletion of CO. I use state-of-the-art cuDisc simulations to model dust-gas dynamics, grain growth, and freeze-out, investigating the impact of these processes on gas-phase CO abundance to understand how CO depletion in wind-driven discs compares with viscous discs.

Debris disc catalogue - I. Herschel PACS photometry

Minjae Kim

The goal of the current study is to present the debris disc catalogue of Herschel Space Observatory observing programmes using the Photodetector Array Camera Spectrometer (PACS), together with the main statistics and scientific results that can be extracted.

Modelling the Dust substructures in the AGE-PRO sample

Lilian Luo

Determining gas mass within protoplanetary disks is crucial for understanding their evolution into planetary systems. AGE-PRO, a recent ALMA Large Program, aims to advance our knowledge of disk evolution by utilising observations of CO and N2H+ across 30 disks spanning three distinct star-forming regions with ages ranging from 0.1 to 10 Myr. Traditionally, gas mass estimates have relied on thermochemical models assuming homogeneous distributions of gas and dust. However, emerging multi-wavelength observations reveal significant substructures within these disks, particularly in dust emission, which may influence these estimates.

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Testing the shock bow model with the variations in exocometary absorptions of high ionized species as Al III observed by HST around Beta Pic.

Cristina Madurga Favieres

Exocomets are small icy bodies composed of rocks and dust that orbit around stars. As they approach their host stars, they sublimate and form a bright envelope of gas and dust around them: the coma. As the material flows into space, two tails are left behind, one of dust and one of ions. Their composition and dynamical distribution are revealed by spectroscopic analysis of the exocomets tails and can be more understandable by comparing them with the comets in our solar system.

The largest amount of exocometary activity observed so far is around Beta Pic, a young and bright star. It is represented by absorption features in the far-UV lines, such as Al III, C III and Si IV. This is particularly surprising as the star is unable to ionize such species by itself. One possible explanation is that, if exocomets approach the star within a few stellar radii, a compressed shock surface front is formed and collisions within it may induce the ionization.

In order to confirm the exocometary shock model, new observations from the Hubble Space Telescope have been proposed. By measuring the blue and redshifted variations of the absorption lines, we get the acceleration exocomets suffer towards and away from the star, and therefore, estimate their distance to it. We are currently analysing the first observations to test the model, which proposes that the Al III line should be detected closer than 5 R*, and to find similarities with known comet shocks in the solar system.

The Effect of Eccentricity on the Accretion Rate onto Newly Formed Planets in Protoplanetary Discs

Aaron Mills

When planets form and evolve in protoplanetary discs, they accrete material from the disc. This material first flows onto a circumplanetary disc, before falling onto the planet. We investigate the significance of the protoplanet's orbital eccentricity on the variability of the accretion rates, and how this affects the planet's evolution. Using the SPH code Phantom, we simulate the evolution of a young planet in a protoplanetary disc. We vary the eccentricity of the planet and measure the accretion rate onto the circumplanetary disc and the planet itself. We find that these accretion rates for a planet on an eccentric orbit may vary by an order of magnitude during one period. Accretion rates which vary to this extent could influence the formation of satellites around the planet.

A Search for Transiting Exocomets in TESS Sectors 1-26

Azib Norazman

Exocomets are interpreted as analogues to comets in our Solar System. While there have been several detections of exocomet-like events using spectroscopic methods, searching for them in photometry is more challenging. However, there have recently been a small number of stars showing such behaviour thanks to the rapid advancements in large-scale surveys in the exoplanet field. The most prominent detection is around Beta Pic, a young A-type star. Recent literature has also indicated that exocomet detections are more likely in younger stars. As TESS carries out an all-sky survey, now is the opportunity to explore this hypothesis further and explore the occurrence rates of exocomets with relation to the spectral type of their host star, uncovering the occurrence rates as a function of spectral type and stellar age.

An automated method to search for exocomets was initially conducted with Kepler. However, necessary updates and considerations need to be conducted for the search with TESS. The updated search algorithm consists of finding the largest transiting events in all TESS lightcurves, determining their shape and amplitude from model fitting, and vetting the remaining candidates to remove false-positive detections. We present the exocomet candidates detected with this search method.

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Dust Dynamics in Protoplanetary Discs after Stellar Flybys

Vasundhara Prasad

Star forming regions are chaotic environments, and we expect that dynamical interactions between protostars, such as flybys, are very common. These interactions can shape the protoplanetary discs around young stars, for example by truncating or distorting them. In this work, we investigate dust dynamics during flybys, focusing our attention on how the solid particle distribution changes during and after a dynamical encounter.

We present results from 3D smoothed particle hydrodynamics (SPH) simulations of a protoplanetary disc undergoing a parabolic flyby from an unbound perturbing star. We vary the periastron distance of the flyby, the mass of the perturbing star and the inclination of the orbit and study the evolution of the gas and dust dynamics in the circumprimary disc during and after the flyby using the SPH code PHANTOM. We focus particularly on the spiral arms induced during the flyby and the increase in dust density in these spirals. Our ultimate aim is to study whether or not the spirals persist for long enough and have a high enough dust density to be favourable locations for planetesimal formation by concentrating solid particles in dust traps.