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THE GENESIS PROJECT

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Abstract. The formation of stars is intimately linked to the structure and evolution of molecular clouds in the interstellar medium. The French-German (ANR/DFG) collaborative project GENESIS (GENeration and Evolution of Structures in the ISm, `http://www.astro.uni-koeln.de/GENESIS`), explores this link with a new approach: by combining far-infrared data of dust (*Herschel*), observations of major cooling lines in the interstellar medium ([C II], [C I], CO, [O I] with the Stratospheric Observatory for FIR astronomy SOFIA), and molecular line maps from ground-based telescopes. It is also supported by the German Government funded MOBS (Modelling SOFIA data). We here present results of two workpackages, one showing SOFIA [O I] observations in the massive star-forming regions S106, and one investigating molecular cloud formation in the diffuse Draco cloud.

Keywords: ISM structure, cloud formation, PDRs, star formation

1 Objectives and methods of GENESIS

To understand the genesis of stars, it is necessary to disentangle the relative importance of gravity, turbulence, magnetic fields, and radiation from diffuse gas, to molecular clouds and collapsing cores, and to study the role of filaments. We use techniques quantifying cloud structure (e.g. Delta-variance) and statistical measures (e.g. N-PDFs) and innovative new analyzing tools developed by the GeoStat team in Bordeaux, to analyze *Herschel* images as well as spectro-imaging surveys from ground-based telescopes, and THz spectroscopy using SOFIA. Various topics are treated within the defined workpackages:
• Understanding how dense structures (filaments, cores,..) are forming.
• Identifying the spatial scales of turbulence dissipation, heating and cooling processes, the H I/H_2 transition.
• Observations covering a large parameter space of density and excitation conditions from diffuse gas to giant molecular clouds, including filaments and dense cores. Assembling a large data set comprising FIR imaging of dust (Herschel) + THz spectroscopy of [C II] high-J CO lines, [O I] .. (SOFIA) + molecular lines + H I.
• Comparison to SPH and MHD simulations, applying the same analysis tools.
• Development and application of novel, non-linear methods of signal analysis.

2 Workpackage gas cooling via far-infrared fine structure lines: S106

The bipolar nebula S106 (`http://hera.ph1.uni-koeln.de/~nschneid/s106.html`) was mapped in FIR cooling lines ([C II] 158 μm, [O I] 63 μm, high-J CO line) with GREAT on board SOFIA (Schneider et al. 2018). Figure 1 shows the line integrated [O I] emission (left) and spectra of the observed lines (right). Modelling the line emission with the KOSMA-tau photodissociation code (Röllig et al. 2006) constrains a radiation field χ of a few times 10^4 and densities of a few times 10^4 cm^{-3}. We interpret the dark lane as an accretion flow and the binary system S106 IR being in a stage of its evolution where gas accretion is counteracted by the stellar winds and radiation, leading to the very complex observed spatial and kinematic emission distribution of the various tracers.

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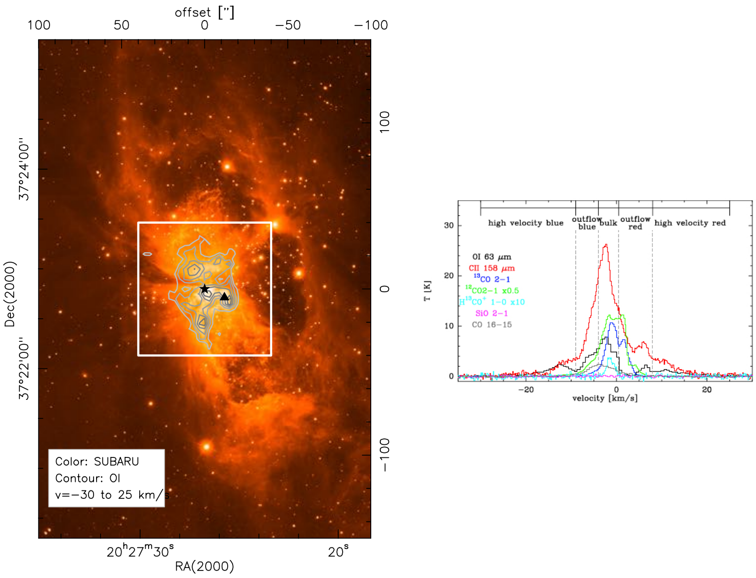

Fig. 1. Left: Near-IR image of S106 taken with Subaru, outlining the bipolar emission nebula, with contours of velocity integrated (30 to 25 km/s) [O I] emission (136 to 456 K km/s in steps of 64 K km/s). The star indicates the position of the S106 IR binary system (Comerón et al. 2018) and the triangle the position of the young stellar object S106 FIR. **Right:** Spatially averaged spectrum of molecular and atomic lines.

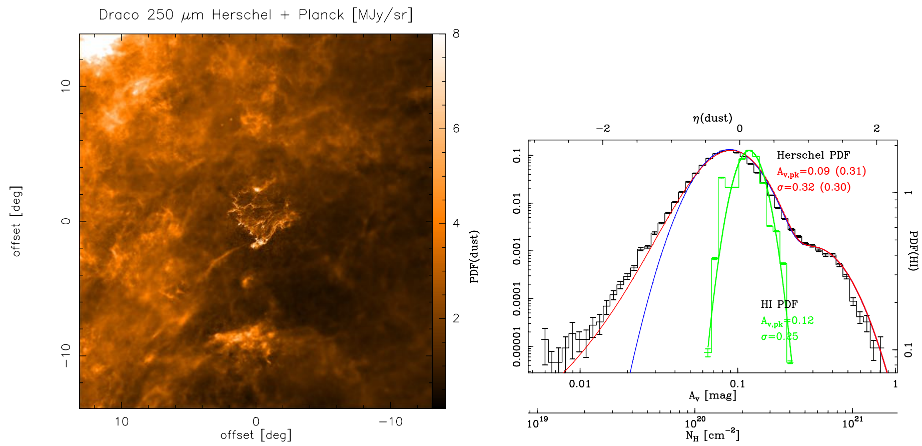

Fig. 2. Left: The Draco cloud (center) at 250 μm. **Right:** N-PDF of total dust column density (black) and atomic hydrogen (green), fitted by two lognormal and a noise tail (red).

3 Workpackage molecular cloud formation: the H I/H_2 transition in Draco

We propose that the diffuse high-velocity Draco cloud (see Fig. 2 for a *Herschel*/Planck map) is an observational example for the dynamic scenario for H_2 formation: converging warm, turbulent H I flows lead to compression of H I gas that cools via thermal instability to form high density molecular gas. This interpretation is deduced from the discovery of a double-peaked probability distribution function of total (H+H_2) gas (Fig. 2) that can be fitted by two lognormal PDFs and a noise tail. The peaks correspond to cold H I (CNM) and H_2, with a transition around Av=0.3.

References

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