Connecting the Large-scale Molecular Cloud Structure and Star Formation

**Introduction:** Star formation has a crucial role in shaping the interstellar medium (ISM). Also, the star formation process itself has its origin in the structure formation within the ISM. This two-way connection between the ISM structure and star formation makes characterizing the evolution of the ISM structure, and processes responsible for it, one of the most profound open questions regarding the ISM today.

The main goal of this project is to connect the large-scale molecular cloud structure to smaller-scale, dense, potentially star-forming structures. Thereby, the large-scale structure will be related to the early cloud evolution and star-forming capability of the clouds, including the threshold for star formation. The project consists of three work packages (WPs) to examine more specific questions related to this goal.

As a preliminary work for this project, we examined in our recent work the column density probability distributions (PDFs) in nearby clouds (Kainulainen et al. 2009, 2011a). Using the PDFs, we proposed a new way to identify cloud structures, and connected the properties of the structures identified with the PDFs to the cloud physics. This project partly aims in further interpretation of these findings and expanding this preliminary work to a more general context.

**WP1: Early Cloud Evolution**

**WP1.1:** Structure build-up in clouds on the brink of star formation. We characterize a sample of starless clouds and compare their properties with star-forming ones (see, e.g., Fig. 1a).

**WP1.2:** Density structure of dynamically coherent dense cores. We characterize in high detail the surroundings of a sample of coherent dense cores in the Pipe nebula (see Fig. 1c).

**WP2: Global Picture -- From Low-mass to High-mass**

**WP2.1:** Revealing the mass reservoirs surrounding Infrared Dark Clouds (IRDCs). We derive a uniformly-defined mass distribution data for a sample of potential high-mass star-forming sites, i.e. IRDCs, using near- and mid-infrared dust extinction mapping.

**WP2.2:** Characterizing one nearby high-mass cloud for reference in higher resolution and sensitivity: Cepheus A.

**WP3: Simulated View**

**WP3:** Connecting the observed structural characteristics to numerical simulations of the ISM.

**References:**


**Fig. 1a:** Two morphologically similar filamentary clouds, one of which is quiescent (Musca) and the other is star-forming (L1495).

**Fig. 1b:** Column density PDFs of a star-forming and a quiescent cloud. In Kainulainen et al. (2011a), we related the change in the shape of the PDFs to the change in the pressure conditions of the clumpy, molecular medium.

**Fig. 1c:** BS globule in Perseus. The structure identified using the PDF of the is shown with the closed black contour, and the dynamically coherent core with a white contour.

**Fig. 2a:** Gas column density map of IRDC G11, derived using a combination of near- and mid-infrared dust extinction mapping (Kainulainen et al. 2011b; Peretto & Fuller 2009, respectively). This method will be applied in WP2.1 for a large sample of IRDC complexes resulting to uniquely high-dynamic-range column density data for them.

**Fig. 2b:** In WP2.1 we examine the structure and cloud energetics of an entire high-mass star-forming cloud (Cepheus A) with near-IR and mm-continuum and CO emission observations. These observations have already been granted. The right panel shows a detail from the CO map, the lower panel shows a low-resolution near-IR dust extinction map.

**Fig. 3:** Example of the evolution of a column density PDF as a function of time in a self-gravitating MHD simulation of driven supersonic turbulence (C. Federrath, priv. comm.). Compare with the observed PDFs shown in Fig. 1b.