

MOLECULAR CLOUD ASSEMBLY WITH SKA OBSERVATIONS

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Abstract. The molecular cloud assembly process sets the initial conditions of star formation and its apparent universal outcome. This might imply a fairly universal molecular cloud formation scenario. Based on studies of nearby clouds a new anisotropic molecular cloud formation scenario was proposed. With SKA precursor observations it will be possible to test its universality in the Milky Way, while SKA observations of nearby galaxies will be able to connect the molecular cloud assembly process to the galactic dynamics.

Keywords: ISM: kinematics and dynamics, ISM: structure, stars: formation

1 Introduction

The ubiquitous filamentary nature of the interstellar medium (ISM) from low-density atomic (H I) filaments to high-mass star forming ridges are an imprint of the physical processes that drive mass concentration leading to star formation in molecular clouds (André et al. 2010; Hacar et al. 2022). Following the dynamics and cooling of these filamentary structures will provide a deeper understanding of star formation and galactic evolution.

2 A universal scenario for molecular cloud assembly?

Combining CO molecular line and H I observations towards the nearby Chamaeleon-Musca complex, we found systematic kinematic anisotropies for denser gas from the large (i.e. ~ 50 pc) down to 0.1-1 pc scales (Bonne et al. 2020). These observations can be explained by a collision in the atomic medium that bends the magnetic and velocity field in an oblique shock as described in e.g. (Inoue et al. 2018), see Fig. 1(left). This scenario might also explain the non-isotropic turbulence statistics in this molecular cloud found with improved multifractal analysis tools (Yahia et al. 2021). The recent review by Pineda et al. (2022) concluded that the observed anisotropic growth of low-mass star forming clouds in the solar neighborhood ($d < 500$ pc) might be driven by these oblique shocks in colliding flows. Analyzing, the massive DR21 ridge in Cygnus-X at a distance of 1.5 kpc, we remarkably found the same kinematic features. This strongly suggests that the massive DR21 ridge was formed through the same mechanism as Musca, implying that the colliding flow scenario might be a common trigger of both low- and high-mass star formation (Bonne 2020).

3 Statistically constraining molecular cloud assembly with SKA and its precursors

The question thus arises whether this scenario indeed is a quite universal trigger of star formation as well as which galactic motion initiates the colliding, mostly atomic, flows.

3.1 Molecular cloud assembly in the Milky Way

With recent high-resolution CO isotopologue surveys (e.g. Mopra-CO (Braiding et al. 2018), OGHReS (Colombo et al. 2021) or CHaMP (Barnes et al. 2011)) it is possible to resolve 1000s of molecular clouds in the Milky Way while the new GASKAP-HI survey (Dickey et al. 2013) will provide H I data at a similar resolution. This will allow to test the proposed cloud assembly scenario in a systematic way on a statistical cloud sample.

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3.2 Molecular cloud assembly in nearby galaxies

High spatial resolution CO observations with ALMA unveiled interesting oscillatory velocity patterns in nearby galaxies (Henshaw et al. 2020), see Fig. 1(right). Combining this with SKA observations, which will have the resolution and sensitivity to trace the HI kinematics in nearby galaxies, will provide new insight into the link between galactic dynamics and molecular cloud formation.

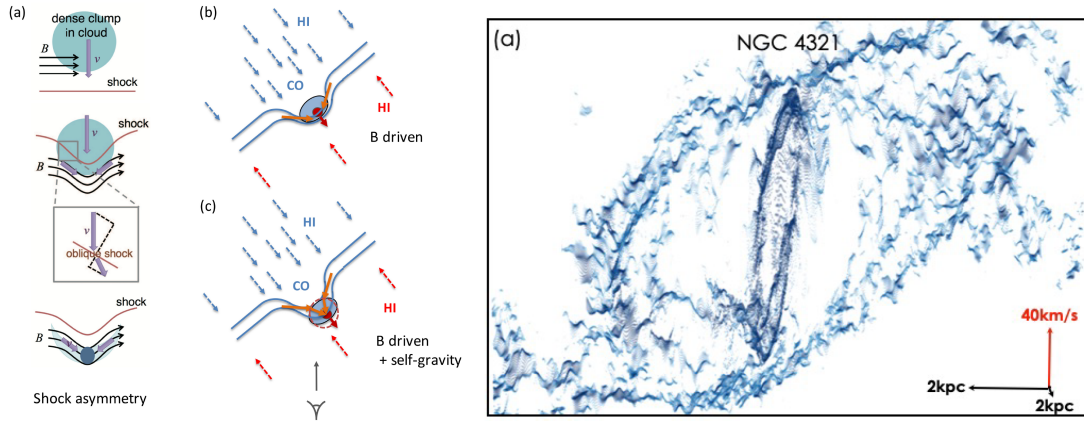


Fig. 1. Left: (a) A schematic representation of magnetic field bending around an overdensity from simulations by Inoue et al. (2018). (b) & (c) A schematic view of the colliding, mostly atomic, flows which explains the observations towards the Musca filament. **Right:** The resolved velocity structure of the nearby galaxy NGC 4321 from Henshaw et al. (2020) based on ALMA CO(2-1) observations. It unveils a wealth of oscillatory motions. Comparing the CO dynamics with SKA HI data will provide a new perspective on the assembly of giant molecular clouds (GMCs).

4 Conclusions

Recent studies have indicated that molecular cloud assembly might be anisotropic, driven by magnetic field bending in colliding HI flows. The operational ASKAP telescope will allow to test the universality of this mechanism in the Milky Way, whereas SKA observations of nearby galaxies will allow to connect molecular cloud formation to the galactic dynamics.

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