Studying the early phases of high-mass star formation

Maxime Valeille-Manet, Sylvain Bontemps, Timea Csengeri and the ALMA-IMF consortium
Laboratoire d'Astrophysique de Bordeaux

The study of the early phases of high-mass star formation is a major topic in astrophysics that is still poorly understood. Several formation scenarios are still in competition. To elucidate which precise processes of formation are in action, it is necessary to identify the youngest precursors of massive stars (M > 8 $M_{\odot}$), even before collapse (so-called pre-stellar cores), within high-mass star-forming regions. Here we survey for massive pre-stellar core candidates (MPSC) in the data cubes of massive proto-clusters mapped in the ALMA-IMF program (ALMA Large Program; Motte et al. 2022). This survey, which images the 15 most massive proto-clusters of the Galaxy located within 6kpc of the Sun, at a resolution of 2700 au, has allowed the identification of 700 compact cores among which we aim at identifying pre-stellar cores.

For this purpose, an automatized method for systematically detecting outflows from proto-stellar cores is developed. Cores without significant outflows are considered as excellent candidates to be pre-stellar cores. For this we compare the spectrum of each source (on source) with the spectrum of its surrounding environment (off source). We use both the CO(2-1) and SiO(5-4) spectral lines to identify outflowing gas. In addition to the spectra, we use outflows maps in order to confirm signs for bipolar outflow around each.

First results show that 46 cores with a mass greater than 8 $M_{\odot}$ are such good pre-stellar candidates in the ALMA-IMF survey (Valeille-Manet et al. in prep). They cover a mass range from 8 to 170 $M_{\odot}$, and for a total amount of around 90 high-mass proto-stellar cores in the survey. Among those 46 cores, 16 have a mass greater than 16 $M_{\odot}$ and are more likely to form high mass stars in the future. This first sample of several MPSC will allow to constrain massive star formation scenarios. In a future work, a complete line analysis of the pre-stellar candidates will be done to study the kinematics and the chemistry undergoing in those early stages of high mass star formation.