From clump to disc scales in W3 IRS4: A case study of the IRAM NOEMA large programme CORE

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Context. High-mass star formation typically takes place in a crowded environment, with a higher likelihood of young forming stars affecting and being affected by their surroundings and neighbours, as well as links between different physical scales affecting the outcome. However, observational studies are often focused on either clump or disc scales exclusively. Aims. We explore the physical and chemical links between clump and disc scales in the high-mass star formation region W3 IRS4, a region that contains a number of different evolutionary phases in the high-mass star formation process, as a case-study for what can be achieved as part of the IRAM NOrthern Extended Millimeter Array (NOEMA) large programme named CORE: "Fragmentation and disc formation in high-mass star formation". Methods. We present 1.4 mm continuum and molecular line observations with the IRAM NOEMA interferometer and 30 m telescope, which together probe spatial scales from ?0.3-20?? (600-40 000 AU or 0.003-0.2 pc at 2 kpc, the distance to W3). As part of our analysis, we used XCLASS to constrain the temperature, column density, velocity, and line-width of the molecular emission lines. Results. The W3 IRS4 region includes a cold filament and cold cores, a massive young stellar object (MYSO) embedded in a hot core, and a more evolved ultra-compact (UC)H II region, with some degree of interaction between all components of the region that affects their evolution. A large velocity gradient is seen in the filament, suggesting infall of material towards the hot core at a rate of 10-3-10-4 M· yr-1, while the swept up gas ring in the photodissociation region around the UCH II region may be squeezing the hot core from the other side. There are no clear indications of a disc around the MYSO down to the resolution of the observations (600 AU). A total of 21 molecules are detected, with the abundances and abundance ratios indicating that many molecules were formed in the ice mantles of dust grains at cooler temperatures, below the freeze-out temperature of CO (? 35 K). This contrasts with the current bulk temperature of ?50 K, which was obtained from H2CO. Conclusions. CORE observations allow us to comprehensively link the different structures in the W3 IRS4 region for the first time. Our results argue that the dynamics and environment around the MYSO W3 IRS4 have a significant impact on its evolution. This context would be missing if only high resolution or continuum observations were available.

HII regions

ISM: abundances

ISM: kinematics and dynamics

Stars: formation

Stars: individual: W3 IRS4

Stars: protostars

Molecules

Degree of interaction

Different structure

Evolutionary phasis

Freeze out temperature

Molecular emissions

Observational study

Photo-dissociation regions

Young stellar objects

Giant stars