The Cygnus X main filament: an exceptional star formation site

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Introduction

The Cygnus X region (Fig. 1, left) is the richest star forming region in the Galaxy at a distance lower than 3 kpc ([1],[2],[3]). More than 40 massive protostars were detected within the Giant Molecular Cloud Complexes of Cygnus X North and South at a distance of 1.7 kpc, including well-known objects such as DR21, DR21(OH), W75N, S106, and AFGL2591. The most massive (~35 000 Msol) from 1CO 2-1 [1] feature in Cygnus X is the dense molecular filament we refer to as the "Cygnus X main filament (CXMF)" [4], containing DR21 and DR21(OH). It belongs to a network of filaments (Fig. 1, middle) that marks active star formation sites.

Recent imaging in near- and mid-IR with the Spitzer satellite ([5],[7]) revealed that the CXMF is forming numerous stars, and our continuum imaging using MAMBO at the IRAM 30m telescope [6], detected several potential sites of OB star formation apart from DR21 and DR21(OH). Follow-up observations using the PdB interferometer reveals the multiplicity of some sources and outflow emission ([8]).

Fig.1: Left: 1CO 1-0 emission of the Cygnus X region (FCRAO 30" resolution, offsets are in arcmin). Middle: Zoom into Cygnus X North in 1CO 1-0 and CI 2-1 (the CXMF is indicated by a rectangle), filaments are indicated by blue lines. Right: Spitzer IRAC 4.5 micron image [7] with CS 2-1 emission overlaid.

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The CXMF was observed in various molecular line tracers using the IRAM 30m telescope (beamsize between 12" and 30"). While in HCO+ and 13CO (Fig. 2), DR21 and its outflow are most prominent, it is the hot core around DR21(OH) that emits most strongly in the optically thin C18O and 12CO- lines (Fig. 3) at a velocity of -3 km/s. Another velocity component (~0 km/s) with cold gas (<10 K determined from N2H+) ‘falls’ on the DR21(OH) core. This is one of the filamentary structures already seen on larger scales. Since N2H+ traces cold, dense gas, it is depleted in the hot core region but prominent more southward (Fig. 2,3). The northern part of the filament is colder and contains several protostellar, dense cores (N2H+ and dust continuum peaks) while C18O is depleted. Active star formation is also indicated by outflows seen in SiO, 12CO, and HCO+ (not shown here).

The whole CXMF may undergo a global collapse because the typical spectral features of infall (Fig. 4, self-absorbed optically thick lines with a higher intensity blue component and the absorption dip redshifted with regard to the optically thin line) are observed across large parts of the filament. The total mass of the CXMF determined by dust continuum is around 20 000 Msol, the one of the DR21(OH) core alone is 7000 Msol, contained in a volume of 1 pc3 at a density of ~6 105 cm-3. Only distant objects like, e.g., W43, W49, or W51, host similar clumps. We estimate that for a "normal" IMF, there would be 300 Msol in OB stars (20 to 25 stars) and 80 Msol in O stars (2 to 3 stars) at the end of the star formation process. No other nearby clump can probe so clearly the OB (and perhaps O) star regime.

Fig.2: Molecular line maps of the CXMF. Known mm-continuum source ([6],[9]) are indicated. The mass obtained from C7N inside the blue polygon is 24 000 Msol and the average density 6.3 104 cm-3 (C34S abundances were calibrated using mm-continuum).

Fig.3: Velocity integrated maps of the -3 and 0 km/s components in HCO+ (gray scale) and N2H+ (contours).

Fig.4: Spectra of different line tracers at the position DR21(OH). Note the self-absorption dip for HCO+ and 12CO.

Literature: