A Neutral Gas Jet in a Low Velocity Shock Front at the Boundary of the Draco Nebula

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Abstract

21-cm line observations with the Westerbork Synthesis Radio Telescope of a dust and molecular filament at the boundary of the Draco Nebula ($\ell \sim 91^{\circ}$, $b \sim 38^{\circ}$) reveal a jet-like neutral hydrogen feature funneling through an outlet in the low velocity shock front at the interface between the Draco Nebula and the surrounding gas. The jet-like feature is apparently connected with a high velocity filament at VLSR = -180 km s^{-1}. We suggest that the soft x-ray emission observed in the area is thermal bremsstrahlung produced by the deceleration of high velocity gas in galactic gas.

Introduction

Dracula, a faint bright nebula (Lynds, 1965) located at $\ell \sim 93^{\circ}$, $b \sim 38^{\circ}$ in the constellation Draco exhibits HI λ21-cm and CO λ2.6 - and λ2.7-mm line emission with a radial velocity of VLSR $\sim$ -22 km s^{-1} in detailed positional agreement (Goerigk et al., 1983) with the faint patches visible at the Palomar Observatory Sky Survey (POSS) red and blue prints (cf. paper I, "The Draco Nebula, a Molecular Cloud Associated with a High Velocity Cloud" by Mebold et al., in the present volume). One of the most striking aspects of Dracula is the filamentary structure of its boundary facing the direction of decreasing galactic longitude, ℓ, and decreasing galactic latitude, b, i.e. more precisely galactic position angle GPA $\sim 240^{\circ}$. HI- line observations with 9 arc min angular resolution show the presence of a positive velocity gradient towards that position angle of about 5 km s^{-1} per 9 arc min for a strech of $\sim 1\overset{\circ}{.}5$ along this boundary (cf. Goerigk et al., 1983). This indicates that Dracula which is approaching us at a velocity of VLSR $\sim$ -22 km s^{-1} is beeing decelerated at this interface.

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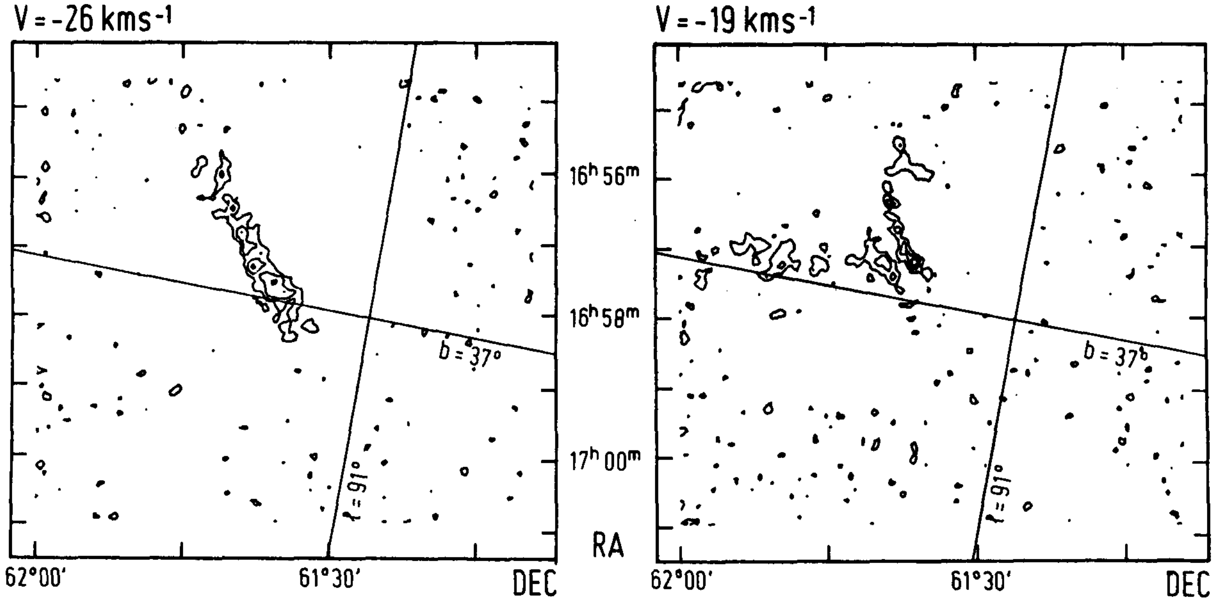

Fig. 1 WSRT channel maps of 21-cm line emission associated with a dust and molecular filament. The contours are at 4,8 and 12 K. Note that the jet-like feature at V= -26 km s^{-1} is centered at the gap which is visible in the map at V= -19 km s^{-1}. The maps which are observed in equatorial coordinates have been rotated by 90° to allow an approximate orientation in galactic coordinates(see Fig. 3).

Results and Discussion

The most prominent filament at this boundary which can be identified at the POSS and in the HI- and the CO lines and which is called Drac 1 in paper I has been observed with the Westerbork Synthesis Radio Telescope (WSRT) in the 21-cm line. The angular resolution is 48 arc sec in right ascension and 55 arc sec in declination. The velocity resolution is 0.5 km s^{-1}. Only a small fraction of the results of three observations can be presented here. In Fig. 1 we present isophotes of 21-cm line brightness temperatures in velocity intervals of 0.5 km s^{-1} width centered at VLSR= -26.2 km s^{-1} (left hand side) and VLSR= -18.9 km s^{-1} (right hand side). This so-called channel maps were chosen to be typical for a velocity intervall of

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-28 to -25.5 km s^{-1} and -19.5 to -17 km s^{-1}, respectively. At the more negative velocities we see a jet-like feature of about 20 arc min length and a width of 2 to 3 arc min at the position where an outlet - like feature at the more positive velocities has its narrow-most opening. We get the impression that the negative velocity gas (VLSR $\approx$ -26.5 km s^{-1}) is funnelled through an outlet in the boundary of Dracula which is formed by gas at a velocity of VLSR $\approx$ -18 km s^{-1}. Adopting the view point that Dracula is moving towards us with VLSR $\approx$ -22 km s^{-1}, it appears that the jet-like feature is accelerated towards us by about 4 km s^{-1} and the outlet is decellerated towards us by about 4 km s^{-1} in the boundary region of Dracula.

The channel maps at the other velocities ($-10 \leq$ VLSR ≤ -35 km s^{-1}) confirm the notion of a deceleration of the boundary region of Dracula with respect to its interior. The velocity gradient is about +5 km s^{-1} per 5 arc min GPA $\approx$ 225^{o}. This is however not so for the notion that the jet-like feature is accelerated towards us. We propose that the jet is decelerated material coming from a high negative velocity cloud filament at VLSR $\approx$ -180 km s^{-1} located about 15 arc min outside the frames in Fig. 1 along the axis of the jet-like feature.

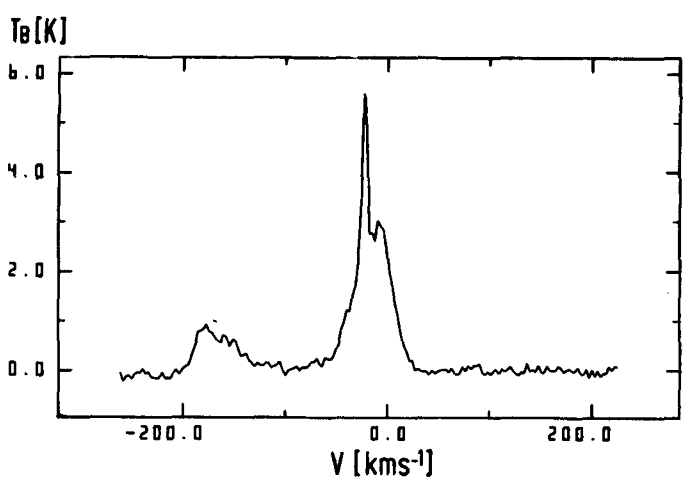

Fig. 2 21-cm emission line from a high velocity filament at V= -180 km s^{-1} located close to the jet-like feature in Fig. 1.
See Fig. 3 for the orientation of the high velocity filament relative to the WSRT field and the jet-like feature.

Fig. 2 shows the 21-cm line spectrum averaged over the spectra observed with the Effelsberg 100-m Telescope at the position indicated by five small crosses (x) next to the frames of Fig. 1 scetched into Fig. 3. In Fig. 2 the high velocity gas is seen with a peak intensity at VLSR $\approx$ -180 km s^{-1} and a tail towards more positive velocieties. This tail indicates that the high negative

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velocity gas is beeing decelerated. The peak at VLSR= -22 km s^{-1} corresponds to the emission of Dracula.

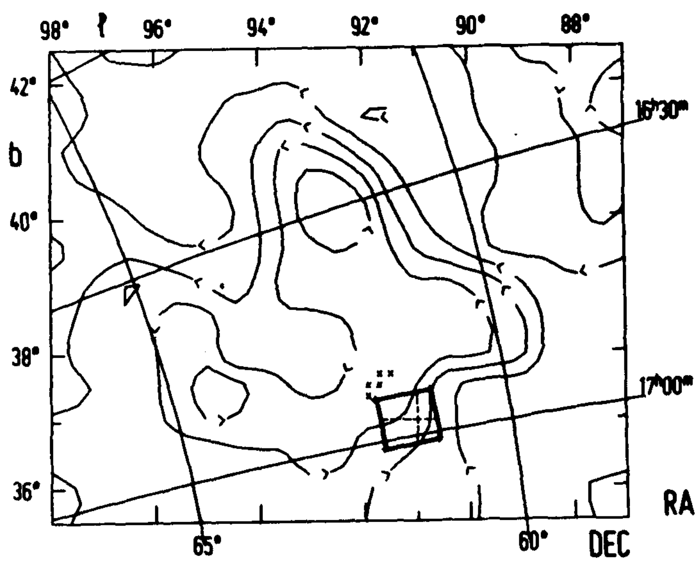

Fig. 3 Large scale distribution of 21-cm line emission at V= -21 km s^{-1} associated with the Draco Nebula. The contours are at 0,2,4,6 and 8 K. Both, galactic and equatorial coordinates are given. The WSRT field-located at the low latitude border of this nebula- is sketched in. The crosses give the positions where the peak emission of the V= -180 km s^{-1} HVC (Fig.2) was observed with the Effelsberg 100-m telescope.

In Fig. 3 the total extent of the VLSR= -22 km s^{-1} emission feature of Dracula is shown in an isophotal representation of 21-cm line brightness temperatures averaged from VLSR= -22 to -20 km s^{-1}. The data are from the Heiles and Habing (1974) survey. We see that Dracula is horse-shoe-shaped with an axis of symmetry roughly in-line with the axis of the jet-like feature in Fig. 1. It is probably more than accidental that this axis is paralled to the direction of the stream of negative high velocity gas extending from $\ell = 120^{\circ}$, $b = 55^{\circ}$ to $\ell = 30^{\circ}$, $b = 20^{\circ}$ (Giovanelli, 1980). Finally we point out that the Darcula complex itself as well as the stream of high velocity gas just mentioned are in a fair positional coincidence with soft x-ray features in the B-, C- and M-Band sky maps of McCammon et al. (1982).

It is therefore very suggestive that the jet-like feature in Fig. 1 and possibly even the whole Dracula complex are related to the high velocity cloud phenomenon and that the soft x-ray emission is thermal bremsstrahlung produced by the interaction of the high velocity gas with the galactic gas. An important link that is missing here could be the discovery of soft x-ray emission between the high velocity filament at VLSR= -180 km s^{-1} and the jet-like feature at VLSR= -26 km s^{-1}.

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