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THE VIOLENT INTERSTELLAR MEDIUM IN MESSIER 31

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ABSTRACT: TAURUS observations in the line of Hα and VLA HI mapping of the HII complex No. 722 in M31, reveal what seems to be a spherical cavity 330 pc in diameter blown out by a stellar association of over 20×10^6 year old. Evidence of induced star formation which was initiated less than 5×10^6 years ago is present in the form of bright HII emission and numerous O, B and Wolf-Rayet stars which are found within the shell surrounding the cavity. The energy necessary to create the HI shell is estimated to be about 5×10^{51} erg.

Vast amounts of energy are pumped into the interstellar medium (ISM) by an OB association, firstly in the form of photons and stellar winds from the most massive stars and later by supernova explosions of all stars initially more massive than about 8 $M_\odot$. The effects that this has on the ISM of spiral galaxies is the creation of large cavities filled with hot gas. Examples of this can be found in recent studies which identify numerous "holes" and shells within the neutral hydrogen (HI) distribution of our Galaxy (Heiles 1979, 1984), the LMC (Meaburn 1980, Dopita *et al.* 1985), M31 (Brinks and Bajaja 1986) and M33 (Deul 1988). There are a number of theoretical studies which describe the energy balance and structure of a supernova dominated ISM (Cox and Smith 1974; McKee and Ostriker 1977). Recently they have been extended to take into account the fact that supernovae occur clumped, *i.e.* they go off within their parent OB association (Heiles 1987; Norman and Ikeuchi 1989). Also, the most energetic events might cause a blow-out of the hot gas and fuel the halo (Bregman 1980; Corbelli and Salpeter 1987). However, what is lacking are observational constraints on these models such as: how is the energy input distributed among the primary sources, how much kinetic energy is dumped into the ISM, and what is the filling factor for each of them. Other interesting questions are: how does an evolving OB association shape its immedeate surroundings and what happens at the interfaces of the various phases of the ISM. Again many models have been proposed (see Tenorio-Tagle and Bodenheimer (1988) for a recent review).

Attempts to answer these questions by studying our Galaxy are frustrated by our location within its disk. Extinction limits our optical horizon to the solar neighbourhood and at radio wavelengths the picture is confused by the lack of reliable distance determinations. We therefore decided to attempt a multi-frequency study of the violent ISM of M31. Part of this study consists of mapping some eight selected areas using TAURUS-I, the Fabry-Perot interferometer mounted at the Cassegrain focus of the 2.5-m INT telescope on La Palma to trace the distribution and kinematics of the ionised gas, or warm phase of the ISM, via its Hα emission. Figure 1 shows a sequence of Hα channel maps of a field located at a galactocentric distance of 9.7 kpc in the north-eastern arm of M31, encompassing region P722 from Pellet *et al.* (1978). The field of view of TAURUS-I is 5 arcmin which corresponds to 1000 pc at the assumed distance of M31 of 690 kpc. The heliocentric velocities corresponding to the channels are indicated on top of each frame. This field coincides with OB48 (van den Bergh 1964; Efremov 1987) which was recently studied in greater detail by Massey *et al.* (1986). They found several Wolf-Rayet stars within its boundaries and estimated it to be young ($< 5 \times 10^6$ year). They also point out that the region seems to consist of subclusters with sizes of typically $\sim$ 200 pc. The Hα shell partly overlaps with an HI shell which was found in the new survey of part of M31 with the Very Large Array (Braun 1989). Its diameter is about 330 pc. Quite surprisingly the shells do not show any sign of expansion. Order of magnitude estimates for the age and energy requirement for the HI shell give 20×10^6 year and 5×10^{51} erg.

Our interpretation of this complex region is as follows. Some 20×10^6 year ago an OB association was formed. During its evolution it created an expanding HI shell. Eventually the shell swept up so much material that it stalled. Densities in this shell reached high enough values for star formation to take place and only 5×10^6 year ago new OB associations were formed which by their strong UV flux ionise most of the HI shell.

These first results illustrate that it is feasible with current instruments to study the violent ISM in nearby galaxies at linear resolutions which could hitherto only be achieved in our Galaxy. Further analysis of this and the other fields is currently in progress.

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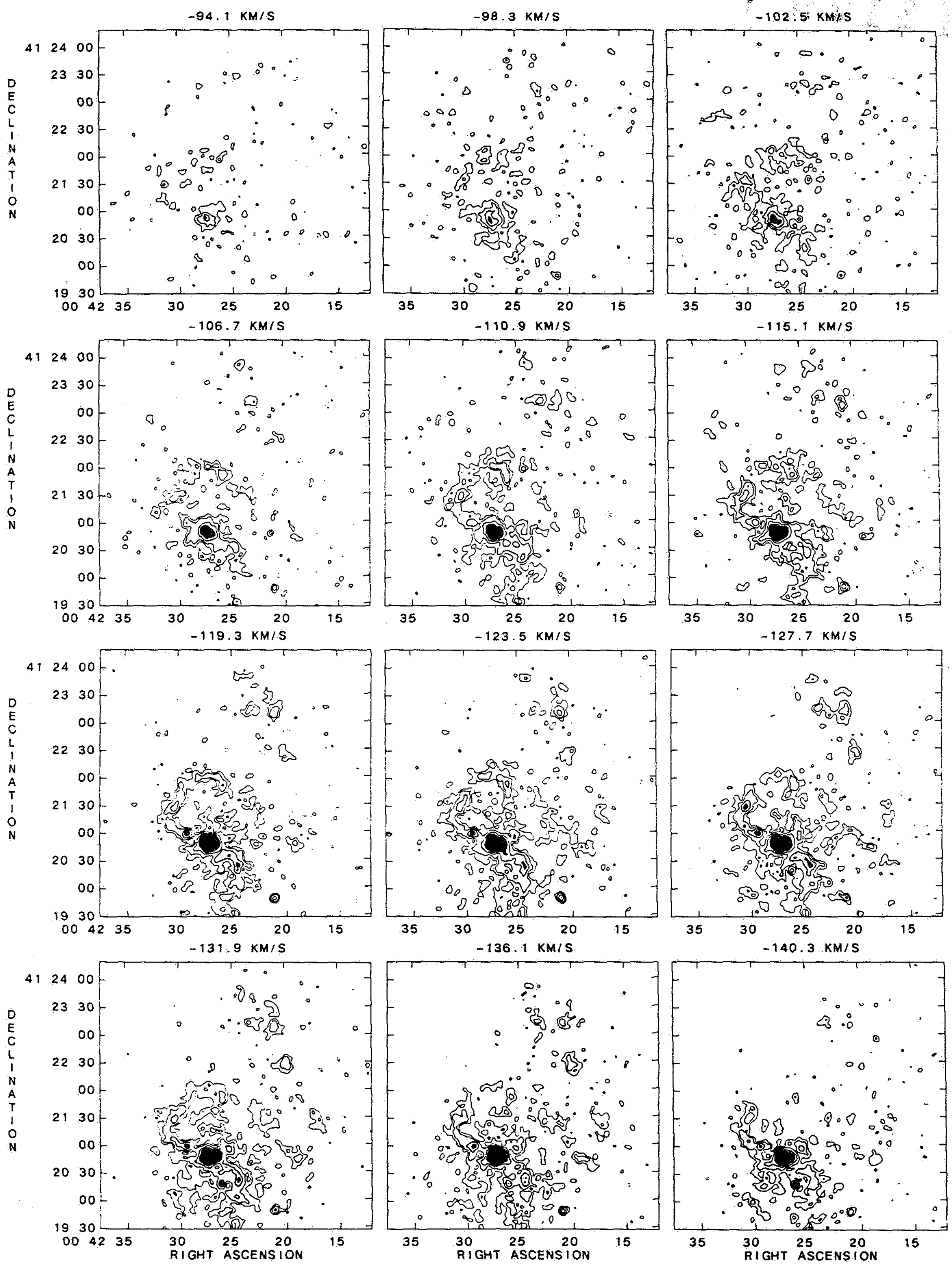

Figure 1: Sequence of Hα channel maps. The heliocentric velocity of each channel in km s^{-1} is shown above each frame. Contour levels are at -1, 1, 2, 4, 8 and 16 in units of 2.14×10^{-17} erg cm^{-2} s^{-1} arcsec^{-2} per channel. The resolution is 5 arcsec, the channel separation 4.2 km s^{-1}.