Neutral Hydrogen in the Starburst Galaxiey NGC3690/IC694

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Abstract:

We have made observations of the neutral hydrogen (HI) emission structure surrounding the very deep absorption peak [observed earlier by Dickey (1986)] in the galaxy pair NGC3690/IC694. This galaxy pair is highly luminous in the far infrared, and known to exhibit extensive star formation as well as nuclear activity. Knowledge of the spatial distribution and velocity structure of the HI emission is of great importance to the understanding of the dynamics of the interaction and the resulting enviromental effects on the galaxies.

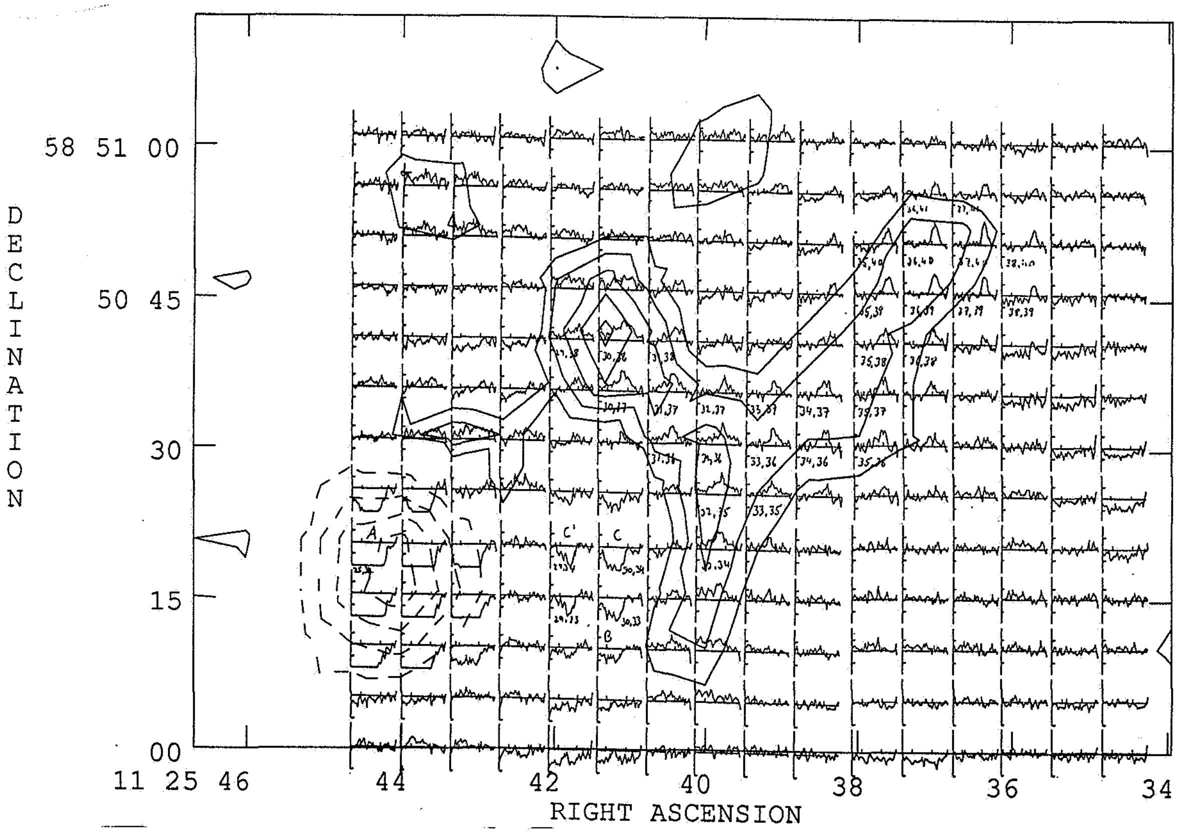

FIG. 1 : This map represents the addition of all the velocity channels that contain emission through the cube (channels 26 - 46). Overlayed on this are the velocity spectra at each point of interest.

Observations:

We observed the system for 12 hours with the Westerbork Synthesis Radio Telescope (WRST), obtaining 64 maps with spatial resolution of 13" x 14" spaced by 8.2 km s^{-1} in velocity (512 km s^{-1} bandwidth).
We reduced the data at Leiden and Minnesota using the AIPS package. We obtained a spectral line cube with 5.2" pixels, where each pixel has a velocity spectrum for its position. Thus, the three dimensions of the cube are right ascension, declination and velocity (or frequency). The velocity range of each spectrum is from 2950 km s^{-1} to 3350 km s^{-1}.

The first step in displaying the emission present in the cube is to search through the channel maps and decide which ones contain emission, and add these together into a single map (see Fig. 1). In Fig. 1, to try to get a feeling for what the cube contains, the velocity spectra for each pixel are also displayed.

Another way to study the spatial and velocity distribution of the HI emission is to fit a gaussian to the spectrum of each pixel and then map the resulting fitted parameters. We use the AIPS task XGAUS to find the integral (zeroth moment) and velocity center (first moment) of the best fit gaussian at each point. Values of the line integral, expressed in units of column density, range from 2 x 10^{21} cm^{-2} to 8 x 10^{21} cm^{-2} across the emission region.

The central velocity varies from 3080 km s^{-1} to 3256 km s^{-1} across the emission region. The northwest plume is moving with velocities consistantly greater than the systemic (3196 km s^{-1}), and with a velocity gradient of about 20 km s^{-1} kpc^{-1}.

We also made l-v diagrams, or position-velocity maps for several cuts through the cube at constant declination. These are shown in Fig.2. Looking through the series it seems that there is more than one velocity component present in the emission region. The two components are well separated in the north; as the slices go to lower declination these components appear to merge. It may be that these are two seperate structures, or two extensions leading off from a central gas cloud.

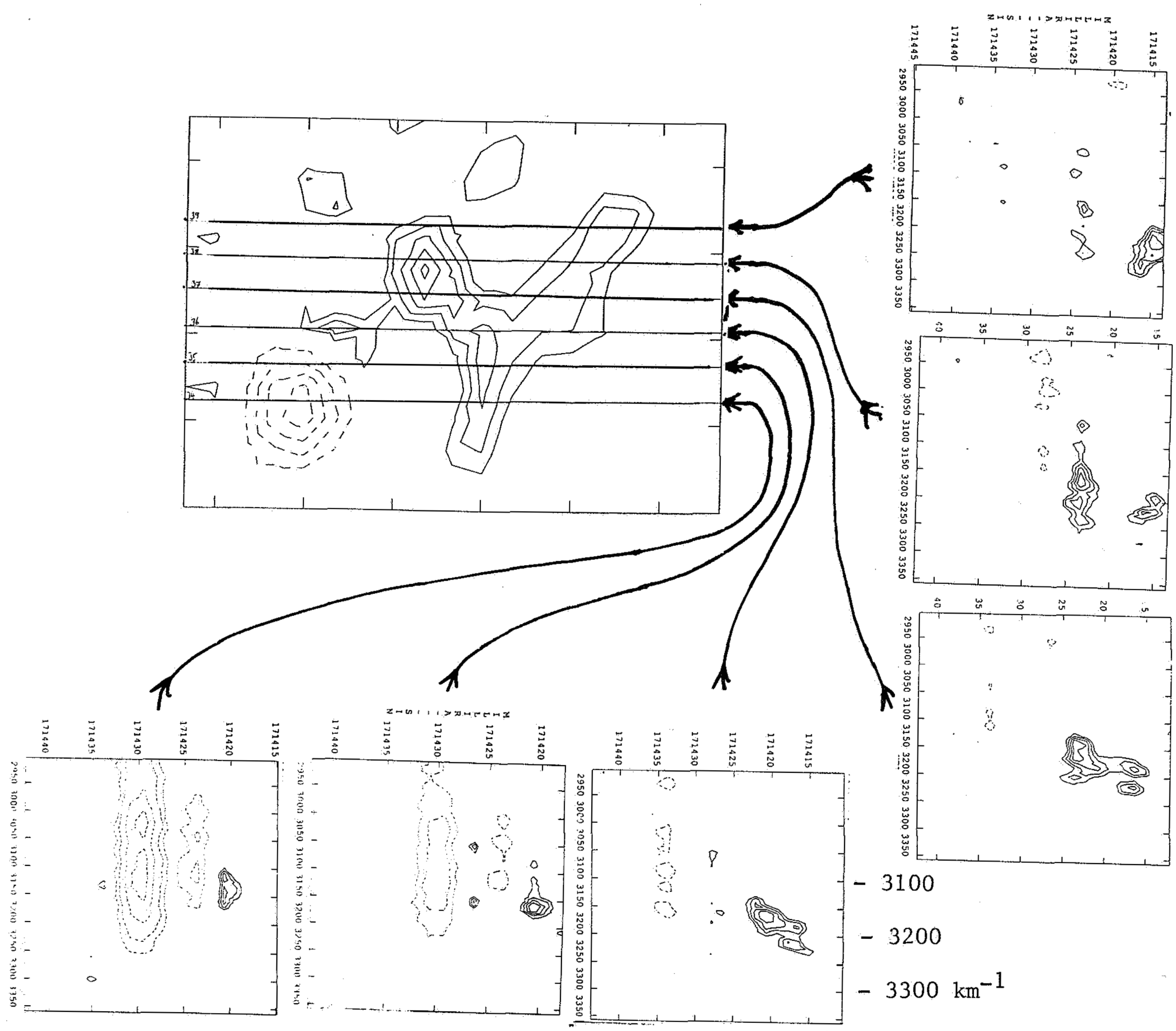

FIG. 2 : Here we have a selection of position velocity cuts through the cube, sliced along lines of constant declination spaced by 6 " as shown on the map.

Results :

We conclude that NGC 3690 + IC 694 is a very complex system, the HI dynamics of which still need some careful work.

At 6 cm and 20 cm Gehrz et al. found four compact radio continuum sources A, B, C, and C'. These seem to coincide with peaks of emission at

10 microns (Gehrz et al.) and the peaks are also discernable in the 2.2 micron map (Telesco et al. 1985). The CO $\int T dv$ map (Sargent et al. 1987) shows high column density concentrations of CO around A and C,C', but nothing is seen at B.

The arm extending 6 kpc to the north-west of NGC 3690 appears to be moving at speeds greater than the central velocity, and could well be the arm of a spiral galaxy aligned skew to our line of sight as suggested by Stanford and Wood (1989). The infra-red polarimetry of Jones (1989) seems to agree with the general alignment of our plume and also the extension seen by Stanford and Wood to the south-east, again giving the impression of a disk-like structure. However, the nuclear core of such a spiral [?] galaxy would appear to be severely misaligned with the spiral arm structure, as seen in the infra-red data (Telesco et al.). From optical and uv spectroscopy Augarde and Lequeux (1985) deduce that NGC 3690 (B,C) and IC 694 (A) are two bodies rotating in opposite senses. They assume the two galaxies are Sb or early Sc type, but conclude that their optical images are too perturbed to be certain. This fits in, in general terms, with what we find. We have yet to confirm the south-west extended structure found by Stanford and Wood, but we should be able to reach their limit with further tapering. Our velocity resoultion is considerably finer, so that a clearer idea of the dynamics of the HI can be obtained.

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