STAR FORMATION ON THE LEADING EDGE OF A RING-LIKE DENSITY WAVE IN ARP 143.

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INTRODUCTION

NGC2445 is a member of the pair of interacting galaxies Arp143 (=VV117) and has been classified as an irregular ring galaxy by de Vaucouleurs et al.(1976). Although not obviously a classical ring galaxy from its optical appearence, it nevertheless shows many of the symptoms of a collisional off-centre ring galaxy in the early stages of development. Optically the galaxy shows a rough ring of super-giant HII regions distributed asymmetrically with respect to the nucleus with most of the emission concentrated on the western side of the galaxy. We have mapped the HI emission in this system (with F.Ghigo and J. van Gorkom ; NRAO) and the observations show that the disk of NGC2445 is characterised by a large-scale banana-shaped HI wave with its peak to the west of the nucleus. (See Fig.1a,b). Near-IR imaging (with E.I.Robson and A.J. Adamson; Lancs. Polytechnic, U.K.) demonstrates that, like the HI, the underlying population of old stars is very asymmetrically distributed with the bulk of the stars concentrated to the western side of the galaxy.

DISCUSSION

The multi-waveband approach to the study of this facinating galaxy pair has revealed some surprising results. On the large scale, the HI observation have shown the presence of a gigantic HI plume extending from Arp 143 some 150 kpc to the north. CCD observations of Arp 143 (with J. Schombert; U.Michigan) have shown that the HI plume has a faint optical counterpart near its base. The plume may be the result of a head-on collision between a gas-rich dwarf disk system and NGC2445, resulting in scattered HI/stars to the north and a ring-like wave in the disk of NGC2445 (See Appleton et al 1987 and in prep.).

Hydrodynamic models of the gas response to such a collision show the development of a banana-shaped wave within the disk of the perturbed galaxy which expands with time to become an irregular ring (See Appleton and Struck-Marcell 1987, hereafter ASM; Struck-Marcell and Appleton 1987,hereafter SMA). The HI emission associated with the disk of NGC2445 shows precisely the distribution one would expect for the early development of an off-centre ring galaxy. The fact that the HI is seen in a rough banana-shaped rather than a complete ring

suggests that the ring is just developing. Indeed the regions of intense starformation are found on the LEADING EDGE of the banana-shaped wave where the HI contours change the most rapidly. These supergiant HII regions do not form a complete ring-like stucture but appear as a set of clumps of intense emission . Radio-continuum emission is also concentrated on the western side of the galaxy where the optical HII regions dominate.

If the HI distribution is indeed the result of an off-centre collision which has induced a wave in the disk, then it should also be observable as a stellar wave. However the optical appearence of the disk is dominated by the young stellar population. We therefore observed the disk of the galaxy at J(1.25 m) H(1.65 m) and K(2.2 m) in the near-IR using the IRCAM array on UKIRT. K-band is well suited to the study of the morphology of the underlying evolved stellar population. The image (Fig 2) shows strong emission from the HII regions (probably from the supergiant population associated with recent starformation) in addition to much more extended emission from the underlying disk. In particular, a fainter ring-like component is observed which is spatially coincident with the brighter HI emission and we associate this with the density wave. The K-band surface brightness in this faint feature has a 2:1 over-density with respect to the unperturbed disk. This is consistant with the overdensity seen in the HI wave of > 1.5:1 , the limit being due to the lower spatial resolution of the HI observations.

Numerical models of star formation in ring galaxies (ASM;SMA) have predicted both the shape of the HI and faint K-band wave as well as the rarefaction behind the wave which is best seen in the HI surface density map (Fig.1). Unlike conventional density wave models of star formation, the above models produce star formation by cloud-cloud collisions. These collisions are found to be intense on the OUTER edge of the expanding density wave. The normally stable equations governing the star formation properties of the ISM in the galaxy are driven out of equilibrium in the expanding wave. If the assumption is made that star formation is a threshold effect, dependant upon principally the mean mass of clouds in the wave, then strong "starbursts" can occur as the wave drives collisions in the LEADING edge of the wave. It would appear that in Arp 143, star formation occurs on the leading-edge of the wave where the collisions between clouds would be expected to be the most intense, rather than on the down-stream side of the density wave. The latter would be expected on the conventional density wave picture where star formation is caused by gas shocking as it falls into the potential well of the wave. Perhaps the clumpy nature of the HII regions in Arp143 is a result of slight irregularities in the original disk which have led these parts to cross the "starburst" threshold earlier than the rest of the wave-front. If so, then Arp 143 will soon turn-on along the whole wave-front, as more of the wave crosses the density threshold , causing it to become a true ring galaxy.

References

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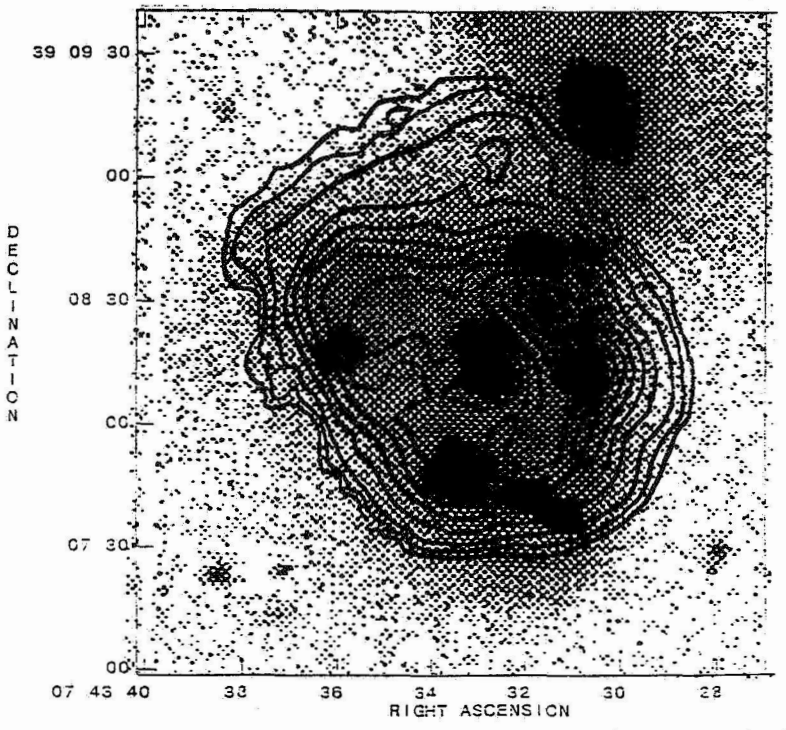

Figure 1a

CONTOURS OF HI SURFACE DENSITY SUPERIMPOSED ON THE B-BAND CCD IMAGE OF ARP 143. HI contours are 3.8, 7.6, 15 x 10^19 at/cm^2, and thereafter in intervals of 1.5 x 10^20 at/cm^2. Major starformation occurs in regions where the HI column densities are in excess of 5 x 10^20 at/cm^2.

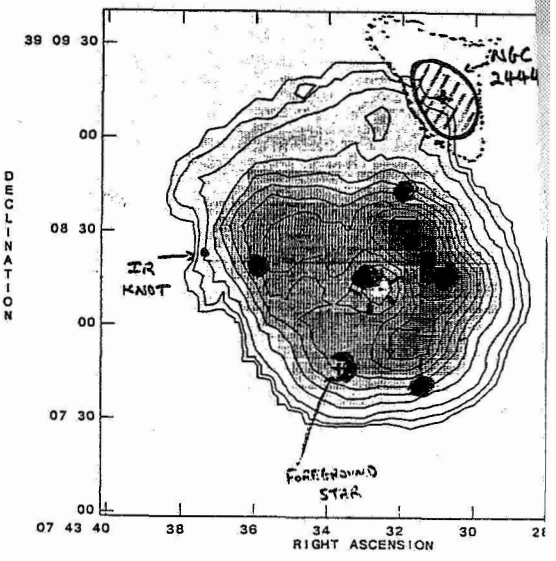

Figure 1b (Showing centres of the optical knots).

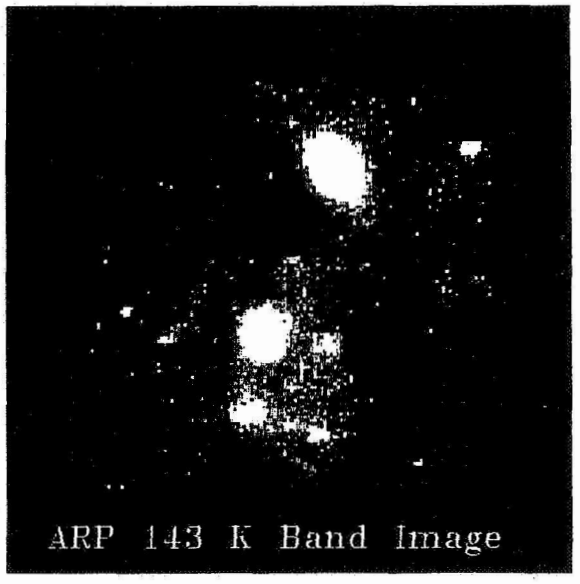

Fig.2 Near-IR K-band image of Arp 143