Final Report Contract #: NAG8–1092 NASA/University Joint Venture in Space Science (JOVE)

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1. Review

This project extended from the summer of 1994 through 1996 and involved a collaboration with Dr. Benjamin Malphrus of Morehead State University, Kentucky. Dr. Malphrus is an Associate Professor of Physical Science at that institution. Ben wanted to learn something about atomic hydrogen observations and galactic structure. With help from JOVE we commenced a study of the peculiar extragalactic system NGC 5291. Ben analyzed data I had previously obtained at the VLA telescope of the National Radio Astronomy Observatory.

This system has an immense complex of optical knots that extend several galactic diameters to the north and south of the main optical object. These are star forming regions, some of which are the size of small irregular galaxies. It has a nearby companion called the 'seashell' owing to its disturbed appearance. The resources made available directly to me through JOVE allowed me to employ Dr. Caroline Simpson (then a senior graduate student, now a faculty member at Florida International University) as the immediate supervisor, under my direction, of Ben's work. This was a very fruitful effort. By the time Ben left in the fall of 1994, the data had been reduced and images formed; a figure is attached.

The high resolution observations show that the atomic hydrogen (HI) encompasses not only the N-S complex of optical knots but it forms an incomplete ring or tail that extends approximately 3 arcmins to the west. The seashell was not detected, and the HI associated with NGC 5291 itself shows a very large velocity range. The formation mechanism for this disturbed and distorted complex is unclear. X-ray emission suggesting ram sweeping is also observed. This author favors an explanation involving an interaction between the two components, NGC 5291 and the seashell. We are witnessing the formation of tidal tails and bridges between the galaxies and the associated ejecta. Ram sweeping occurs as the system moves bodily through the medium of the cluster of galaxies, Abell 3574, to which NGC 5291 *et al.* belong.

There are numerous concentrations of HI, mostly along the N-S star forming complexes which generally coincide with the optical knots; the larger features contain several $\times 10^9 M_\odot$, again the magnitude of a small irregular galaxy. Each knot was compared to a set of criteria designed to test if the feature was stable against its own internal kinetic energy, and stable against the tidal forces of the host galaxy. At least one of the objects (Knot B) appears to be a bound system suggesting that it is a genuinely young dwarf irregular galaxy that has evolved from the material associated with his interacting complex. We conclude that we are witnessing the early evolution of young galaxies and that NGC 5291 and the seashell are a nursery.

The results of this work were discussed at meetings of the American Astronomical Society in 1995 and 1996. At the latter, an announcement was made by the AAS concerning this project and its importance for our understanding of the formation of galaxies. A paper has been published in the *Astronomical Journal* ['NGC 5291: Implications for the Formation of Dwarf Galaxies', B.K.Malphrus, C.E.Simpson, S.T.Gottesman and T.G.Hawarden, *Astron. J.*, **114**, 1427–1446.]. In addition, two grant proposals were submitted to the NSF, the latest on 03 November, 1997 entitled 'Colliding Galaxies: The Evolution of Interactions and Tidal Dwarfs'. This project involves not only Drs. Malphrus, Simpson and Gottesman but several Spanish collaborators from the Instituto de Astrofisica de Canarias (IAC). Their expertise is in the area of optical and infrared observations.

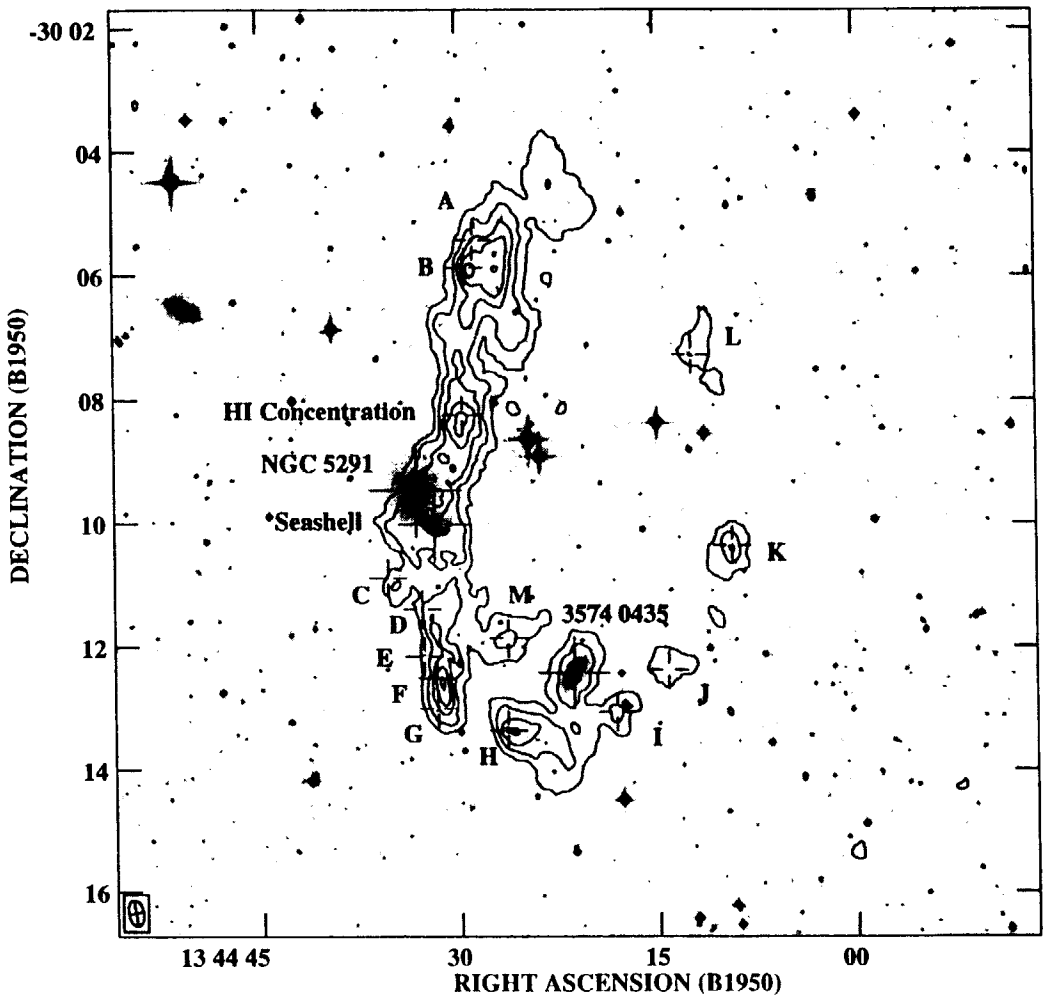

FIG. 4. Contours of the H I integrated intensity from the C+D combined array data superimposed over the digitized optical image from the UK Schmidt IIIaJ Sky Survey plate. Contour levels are $1.1(2\sigma)$, 5, 10, 15, and 20×10^{20} atom cm^{-2}. The beamsize ($26''\times15''$) is indicated by the ellipse in the lower right corner. Optical and H I knots are indicated with labeled crosses.