R 136—Source of Excitation of the Tarantula Nebula

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Among the few extragalactic objects that can be seen with the naked eye, the LMC and its Tarantula Nebula (30 Doradus) are perhaps the most impressive. This nebula, a giant region of ionized hydrogen, has long attracted astronomers and has been extensively studied with a large variety of telescopes. Drs. Johannes Feitzinger and Theodor Schmidt-Kaler from the Astronomical Institute of the Ruhr University in Bochum, FRG, have recently obtained extremely interesting observations of the central stars in the Tarantula Nebula. It would appear that one of these objects, R136, could be the most massive single "star" that has yet been discovered.

The Centre of LMC?

One of the most fascinating objects in the Large Magellanic Cloud is the Tarantula Nebula (30 Doradus). It is a supermassive H II complex, unique in the whole LMC and in many respects similar to the supermassive H II regions in the centre of spiral galaxies. Like these, it is the starting point of the spiral filaments formed by the extremely young population of the Large Magellanic Cloud, and—again similar to many galactic nuclei—it shows evidence of mild activity.

These results, which we arrived at in 1975, have since been confirmed by many investigators, notably Elliott, Meaburn, Blades, Cantò and their co-workers. Contrary to nuclei of normal galaxies, however, the Tarantula Nebula is not situated in the centre of the galaxy. This may be linked to the activity of a galactic nucleus in a galaxy of comparatively small mass with a correspondingly flat, central po-

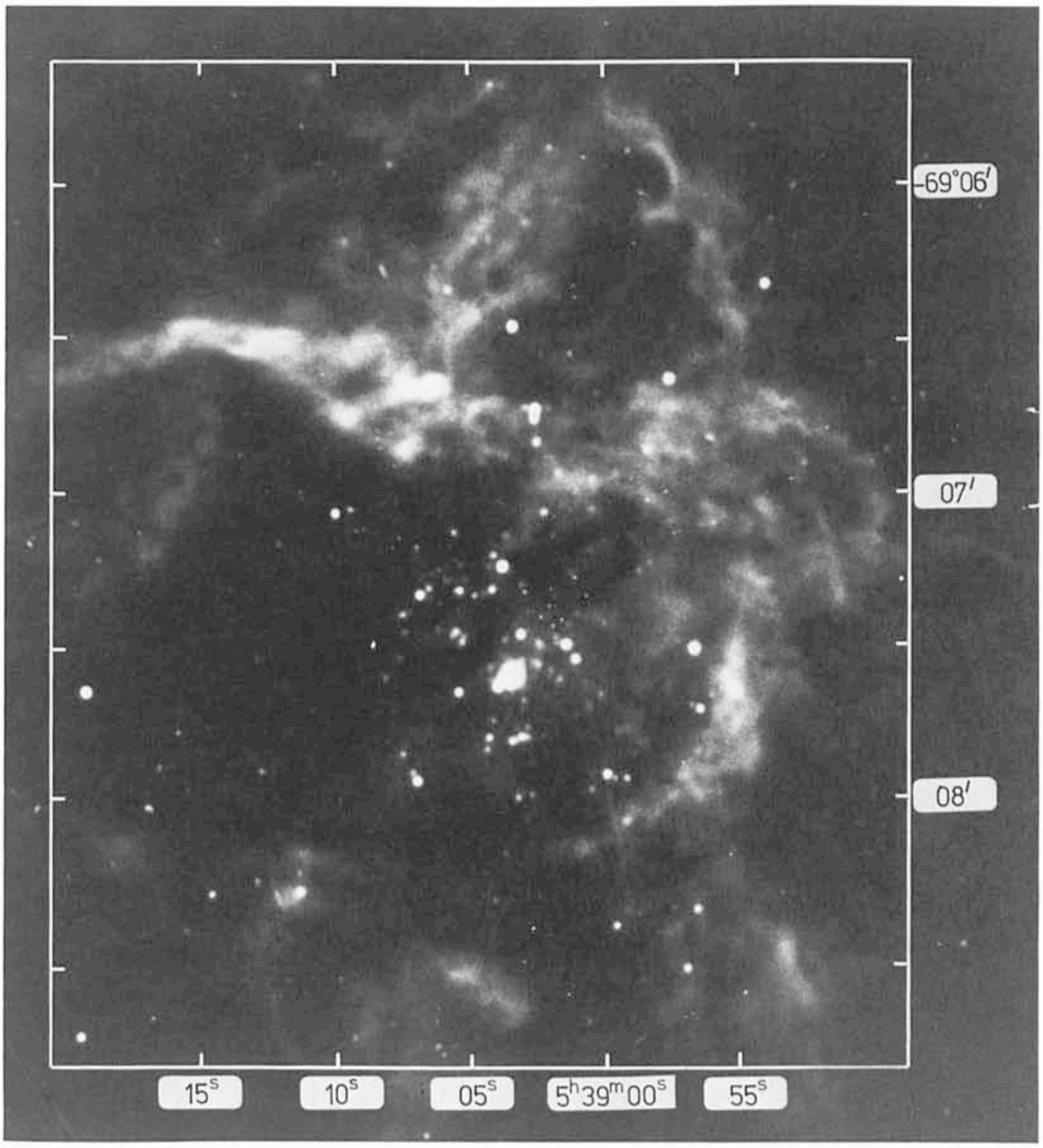

Fig. 1: *Hα photograph of 30 Doradus (3.6 m ESO telescope, 2 min exposure on 127-04, $\Delta\lambda$ = 220 Å).*

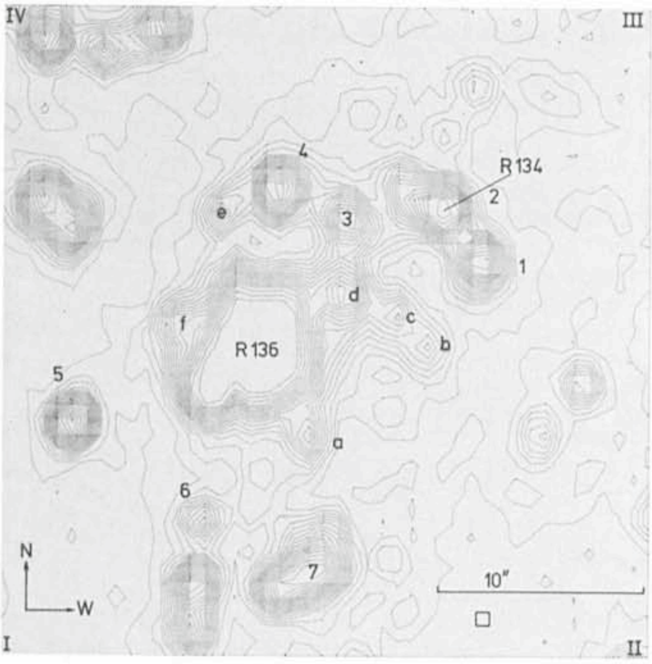

Fig. 2: *Isophote plot of the central stellar group (1–7: stars; a–f: condensation). The rectangle represents the photometer slot.*

tential well. In a massive galaxy with a deep potential well in its centre, even a very violent asymmetric explosion of the nucleus will not be able to move the nucleus considerably out of the centre. However, in a low-mass galaxy like the LMC such an explosion can lead to a large displacement of the nucleus from the geometrical centre and give rise to a basic asymmetry which subsequently determines the appearance of an irregular galaxy.

Such considerations make 30 Doradus even more interesting, apart from the fact that it is also by far the nearest supermassive HII region to be studied outside our own Galaxy.

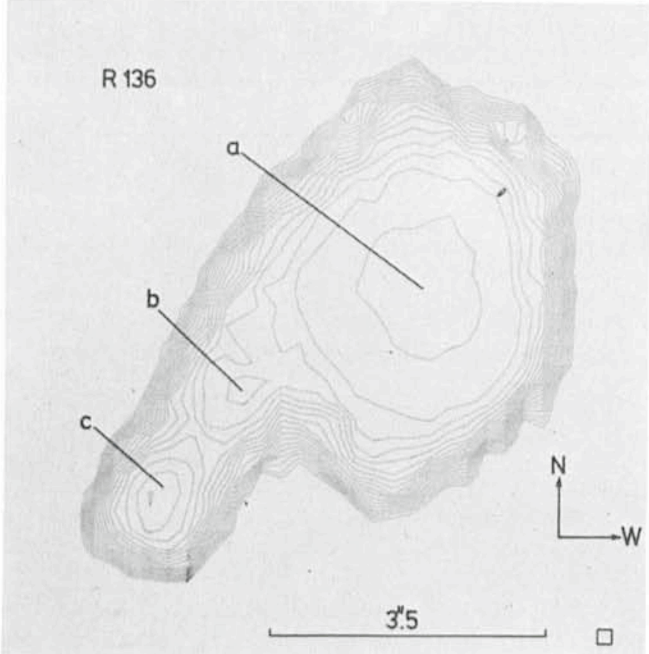

Fig. 3: *The object R 136 with the three components a, b, c.*

The first question is of course: what makes this enormous nebula shine? Feast, Fehrenbach, Azzopardi and Melnick discovered near its centre a dozen Wolf-Rayet stars, an O8 star and three B0.5 stars. Although these Wolf-Rayet stars are all considerably too luminous for their type, there is one outstanding object among them: Radcliffe No. 136. It is more than three magnitudes brighter than the next-brightest star there, it appears nebulous, and it shows emission-line profiles corresponding to an expansion velocity (projected on the plane) of 50 km/sec. Many ultraviolet absorption components at $+270 \pm 20$ km/sec have also been seen in IUE satellite spectra, but they have been attributed—in an alternative interpretation—to a galactic halo around the whole LMC. If that is true, then these lines should also be present in the spectra of other LMC OB stars as well! Furthermore, R 136 shows CIV P Cygni profiles with an expansion velocity of 3,300 km/sec which is far beyond the range of all normal WR stars.

Observations at La Silla

A better understanding of R 136 will certainly give important clues to understand supermassive HII regions, galactic nuclei and their excitation mechanisms. So a series of short-exposure fine-grain plates was obtained at the Cassegrain focus of the Bochum 61 cm telescope and at the prime focus of the 3.6 m ESO telescope in UBVR and the near IR as well as Hα (cf. fig. 1); in addition, spectra were secured with the ESO 1.5 m telescope, and spectrophotometric scans were made with the Bochum telescope. The plates of best seeing have been treated by modern image analysis, i.e. they were scanned, and noise filtering, contrast enhancement, and background suppression were applied. The pixel-size was $0''.8 \times 0''.8 = 0.2$ pc x 2.2 pc, which is about half the smallest recognizable structure, cf. figs. 2, 3 and 4.

R 136 appears to be located in the centre of a slightly elliptical shell of gas of about 16 pc diameter which in turn is at the centre of the curved luminous arcs extending from the inner regions of the Tarantula nebula. The object itself is clearly resolved into three components of $4''.3$ or 1.1 pc distance. Component "a" with less than 1 pc diameter (fig. 3) contributes most to the whole luminosity and has by far the bluest colour U-V = –0.99, while component "c" has U-V = –0.44.

What is R 136?

R 136 has been interpreted as a very compact group of early O-type and Wolf-Rayet stars. In order to account for its luminosity, 50–100 such luminous stars ought to be packed together within a cluster of less than 1 pc diamter! That has never been observed. Furthermore, present ideas on star formation preclude the formation of more than a few very massive stars in one cluster. We therefore assume that R 136 is a single object.

We estimated its reddening from the colours observed and the interstellar extinction, using the normal interstellar extinction curve. We arrived at the tremendous luminosity $M_v = -10.5$. The temperature can be estimated at 50,000–55,000 K. This is just the temperature of HD 93250, the earliest O-type star known, which was recently determined by Kudritzki in Kiel, using non-LTE models (see *Messenger* No. 15, p. 26). The bolometric correction of such stars is not very well known; Morton's estimate is for WN5 and O5-8 between $-2^m.8$ and $-4^m.7$. Conservatively

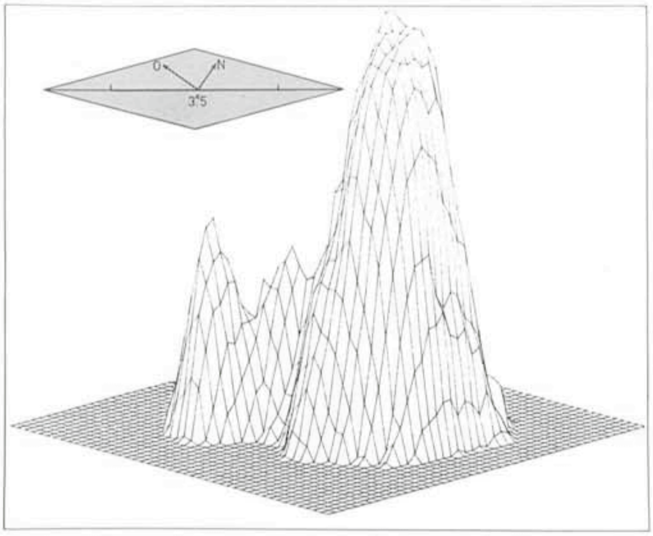

Fig. 4: *Three-dimensional representation of R136. The background intensity has been suppressed, the contrast enhanced.*

taking -3^m5, we arrive at $L = 3 \times 10^7 L_\odot$. The Lyman continuum flux of such an object is more than 5×10^{51} photons/sec. This yields an excitation parameter of 555, while the total value observed for the inner 1,000 pc of 30 Doradus by radio astronomers Churchwell and Walmsley is $U = 630$ pc/cm^2. Indeed, together with the 15 remaining OB and WR stars, $U = 625$ pc/cm^2 results.

What is the mass of this extremely luminous object? Certainly, its gravitation must be strong enough to prevent it from disruption by radiation pressure. The only important opacity source in such a very hot atmosphere is pure electron scattering. Thus we arrive at the Eddington limit at a mass between 200 and 1,000 $M_\odot$, depending on the hydrogen content. This is already in the mass range of supermassive objects—an intriguing idea!

Explaining the shell around R 136 as being due to a massive stellar wind we arrive at an age of that shell of 3×10^5 years—and that is just of the order of the life time of supermassive stars. The initial density turns out to 200 cm $^{-3}$, the total energy of the shell to 10^{51} ergs which might also indicate that a number of supernova explosions may have occurred.

The basic assumption of a single star has still to be confirmed. At our request Gerd Weigelt from the Institute of Applied Optics of the University of Erlangen obtained speckle photometry at the 3.6 m telescope (cf. *Messenger* No. 18, p. 24). He is presently reducing his data. We are most eagerly expecting his results!

Acknowledgements

Dr. Wolfhard Schlosser and graduate student Christoph Winkler contributed essential parts of the work described, which is to appear in *Astronomy & Astrophysics*. The methods of image processing used are described by Dr. Manfred Buchholz, Dr. Tobias Kreidl and Christoph Winkler on page 21.

NEWS AND NOTES

ASTEL—a FORTRAN Programme to Decipher IAU Telegrams

Astronomers have a long tradition of exchanging urgent information by telegram or, more recently, by telex. This concerns mainly new discoveries that must be followed up by other observers, e.g. moving objects like minor planets and comets, or variable sources, like supernovae, etc.

To keep the cost down, a special code has been devised which consists of five-digit groups, interspersed with information about the discoverer, the orbit computer, etc. This code is not difficult to interpret and many astronomers can read an astronomical telegram without having to consult the explanatory manual.

Nevertheless, it sometimes happens that this manual is temporarily misplaced or that somebody with little or no experience has to decipher a telegram. Moreover, to decode a long telegram takes a certain time. To facilitate this task, a FORTRAN programme has now been written, which allows the user to simply type in the telegram groups, one after another, and following the last, the programme will print out the entire text in clear language. The programme also checks the various control numbers in the telegram in order to discover possible transmission errors.

The programme has been implemented on the ESO HP computers at La Silla and in Geneva. With the possible exception of the input/output format, it should be easy to install it in any computer that can compile FORTRAN programmes. Xerox copies of the programme (the source file) are available at request from R. West, ESO c/o CERN, CH-1211 Geneva 23, Switzerland.

ALGUNOS RESUMENES

Bienvenido a La Silla!

Un «nuevo» telescopio se encuentra operando en La Silla desde fines de marzo de 1979. El telescopio fotométrico de 90 cm de la Estación Austral de Leiden en Sudáfrica fue ya instalado en el año 1958, y se decidió su cambio a La Silla debido a las deterioradas condiciones de observación existentes allá, causadas principalmente por la polución proveniente de las cercanas ciudades de Pretoria y Johannesburgo. El instrumento se encuentra actualmente instalado en el antiguo edificio del telescopio de 1 m, conocido también como cúpula del «Chilimap». Tal como se había esperado está trabajando perfectamente en su nuevo ambiente y de él se espera que alivie en algo la gran demanda que existe para observar con el telescopio fotométrico de 1 m de ESO.

La Silla en el cielo ...

En su edición del 1° de diciembre de 1979 el «Minor Planet and Comet Circular» hace referencia a un nuevo planeta menor recientemente descubierto, el 1976 UH, enumerado (2187) en la página 5036, y nombrado LA SILLA en la página 5039.

La dedicación dice: «Nombrado por el cerro situado en el Desierto de Atacama en cuya cima se encuentra el observatorio Europeo Austral». Es interesante notar que el tamaño del nuevo planeta no difiere mucho del cerro La Silla, y – en vista del permanente aumento del riesgo de la polución (luminosa y atmosférica) que amenaza a muchos observatorios (sin embargo por cierto no a los establecimientos de ESO actualmente) – uno se pregunta si no se estará presenciando un ejemplo extremo de planeamiento a muy largo plazo?!