core will exert radiation pressure on the dust in the accreting material. Calculation[1] suggests that above about $60M_\odot$ the pressure transmitted to the gas through collision with the grains should be enough actually to halt the inflow. Thus a star could grow no further.

Given these limiting mechanisms it is not surprising that considerable excitement greeted the report of observation of a $2,500M_\odot$ in the 30 Doradus nebula by Cassinelli *et al.*[2] in 1981. These authors strengthened the previous suggestion of Feitzinger *et al.*[3] that the central part of the nebula contained an object of $250–1,000M_\odot$ The basic arguments in favour of such a large star were fourfold; the implied ultraviolet flux required to ionize the nebula, the characteristics of the ultraviolet absorption spectrum (as observed by the IUE satellite), the surface brightness on the sky where the object is situated (known as R136 from a Radcliffe Observatory catalogue), and the suspected intrinsic variability. The ultraviolet flux required to power the nebula after other hot stars had been taken into account suggested a need for the equivalent of 30 very hot (03) stars within the, apparently stellar, R136 image. The ultraviolet spectrum suggested a single star with high velocity (up to 3,400 $kms^{-1}$) mass outflow. The surface brightness of the R136 image suggested a luminosity far in excess of that expected from a $100M_\odot$ star, and the variability implied a single object rather than many. Further support for a single star was given by speckle interferometry[4], that ingenious technique of using the instantaneous structure of images (which are inevitably blurred by terrestrial atmospheric motions) to set upper limits on the size of an unresolved object. The suspected size limit (set by the aperture of the telescope) was less than, or possibly just resolved at 0.02 arc seconds. The expected diameter of a $2,500M_\odot$ star would be much smaller than this (about $2 \times 10^{-5}$ arc seconds), but even at 0.02 arc seconds a cluster of normal stars providing the nebular ionization would have to be surprisingly dense.

Along with a spirited and updated restatement[6] of the arguments for the presence of a very massive star, two papers have appeared[4,5] claiming that the region is really not so peculiar. The ultraviolet spectrum, it appears, is not too unusual and could be produced by the superposition of the spectra of a few hot O-type stars and a bright Wolf-Rayet star. Wolf-Rayet stars (of which several are found elsewhere in the nebula) are very hot stars which show a particular broad-line emission spectrum with chemical peculiarities. They are reasonably well understood as massive (but certainly less than $100M_\odot$) stars which have been stripped down towards their core by mass loss. They have lost hydrogen, in particular, and show the products of nuclear processing, possibly often involving the simultaneous evolution of (and mass exchange with) a binary companion. Exotic objects indeed, but still within the accepted stellar mass range.

The interpretation of the surface brightness of R136 depends critically on the assumed absorption by dust in the nebula, and between the nebula and Earth. Its surface brightness (as limited to finite size by the Earth's atmosphere) may in fact be less than that which a cluster of stars NGC 3603 in our own Galaxy would have if it were at the same distance as R136. The cluster NGC 3603 is clearly resolved into stars simply because it is nearer to us. A reassessment of photometry, and new photometric observations, suggest that R136 is not variable — removing the necessity of a single coherent object. Even the speckle interferometry result is cast into doubt. An independent study[7] has resolved the object into at least two stars — and indeed this double was actually resolved visually (at about 0.5 arc second separation) by an indefatigable observer of double stars, Innes[8], working in South Africa in the 1920s. The resolution of such small scale structure, below the typical single image size of 1–2 seconds of arc caused by the smearing by the atmosphere, is possible either on nights of exceptional atmospheric conditions or by the eye and brain acting as a sort of real-time auto-correlator of the image structure. The eye can respond to what used to be called 'the image within the image'; effectively a doublet structure within the transient speckles making up the image structure. The failure of the other speckle interferometry group to resolve the source as double may have been due to the particular design of their image processing system.

Further investigation of the image structure will be essential, since the physical extent of R136 is crucial to the arguments for or against a single star. If the majority of the luminosity really comes from a source smaller than 0.02 seconds of arc then the single-object hypothesis would be hard to resist, both because of the abnormally high density implied for the required star cluster and the resulting very short implied dynamical lifetime[6] (of order only 1,000 years!) for such a dense cluster. If the region really has its luminosity spread out in several objects over an image of say 0.5 to 2 seconds of arc, then the cluster hypothesis is preferable. Unfortunately, the interpretation of speckle interferometry of almost anything other than simple point or double sources is a difficult (and at present unsolved) problem for astronomical objects which are relatively faint when viewed from Earth.

One other important question does not seem to be entirely settled, and that is the number of normal stars needed to supply the ultraviolet radiation required by the observed nebular re-emission. The Wisconsin group[6] maintain that some 30 stars are required, but Melnick[4] suggests that stars outside R136 can supply all but 30 per cent of the ionizing flux and that only five to eight hot O stars are actually required inside R136. This brings us back to Walborn's original suggestion[9] that R136 is just a dense star cluster of hot, but not exceptional, stars.

The recent results are perhaps something of a disappointment. Very massive stars (which eventually become black holes) built up by agglomeration in a dense star cluster are popular models for active galactic nuclei. A single black-hole-plus-accretion-disc model for R136 is probably not viable both because it is an extended, rather than a strong point-like, X-ray source and (more importantly) because of its star-like optical and ultraviolet spectrum. It could be argued that the radiation-pressure-on-dust mechanism for stopping very massive star formation might not work so well in the Magellanic Clouds where heavy element abundances, and certainly the abundance of dust formed from such elements, is lower than in our own Galaxy. A favourite device of theorists considering star formation during the formation and early evolution of galaxies has been to suggest that much more massive stars were able to form when overall abundance of the heavy elements was low. Studies of other galactic systems with low abundances and the chemical evidence in old stars in our own Galaxy may eventually help to establish whether very massive stars (other than in galactic nuclei) are more than a theoretician's dream, but the *prima facie* case for observation of such a star in the Magellanic Clouds seems to be weakening under cross-examination. □

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1. Kahn, F.D. *Astr. Astrophs.* **37**, 149 (1974).
2. Cassinelli, J.P., Mathis, J.S. & Savage, B.D. *Science* **212**, 1497 (1981).
3. Feitzinger, J.V., Schlosser, W., Schmidt-Kaler, Th., & Winkler, Chr. *Astr. Astrophys.* **84**, 50 (1980).
4. Melnick, J. (1983) *ESO Messenger*, June 1983.
5. Moffat, A.F.J. & Seggewiss, W. *Astr. and Astrophys.* **125**, 83 (1983).
6. Savage, B.D., Fitzpatrick, E.L., Cassinelli, J.P. & Ebberts, *D.C. Astrophysical Journal* **273**, 597 (1983).
7. Weigelt, G. quoted in refs 5 & 6.
8. Innes, R.T.A. *Southern Double Star Catalogue* (1927).
9. Walborn, N.R. *Astrophys. J. Lett.* **182**, L21 (1973).

## 100 years ago

In a letter dated Tokio, October 3, Prof. James Main Dixon writes:— "During the two or three days at the end of August we enjoyed fine dry weather, but the sun was copper-coloured and had no brightness. When we got to Nikko, the people came to us to inquire if some catastrophe were impending, for the appearance of the sun foreboded evil. We laughed at their fears, and assured them all was right. However it seems that if the appearance of the sun foreboded no evil, it was a wonderful sign of the greatest earthquake and volcanic catastrophe on record. The fearful explosion of Krakatoa, took place on August 26, and there seems little reason to doubt that the monsoon had carried the volcanic dust along with it, the dust obscuring the sun. The distance is nearly 3000 miles."

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