Diffraction-Limited K-Band Observations of the Star Cluster R136

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Introduction

The 30 Doradus region in the LMC is the largest Giant HII region in the Local Group. Although its diameter is only about 200 pc, it contains a stellar mass of more than $5 \times 10^5 M_\odot$. The bolometric luminosity in its centre is 50 times larger than in the inner 0.2 pc of Orion and its stellar density is a million times larger than in our solar neighbourhood. The ionising radiation is produced by the massive early-type stars of the stellar cluster NGC 2070,

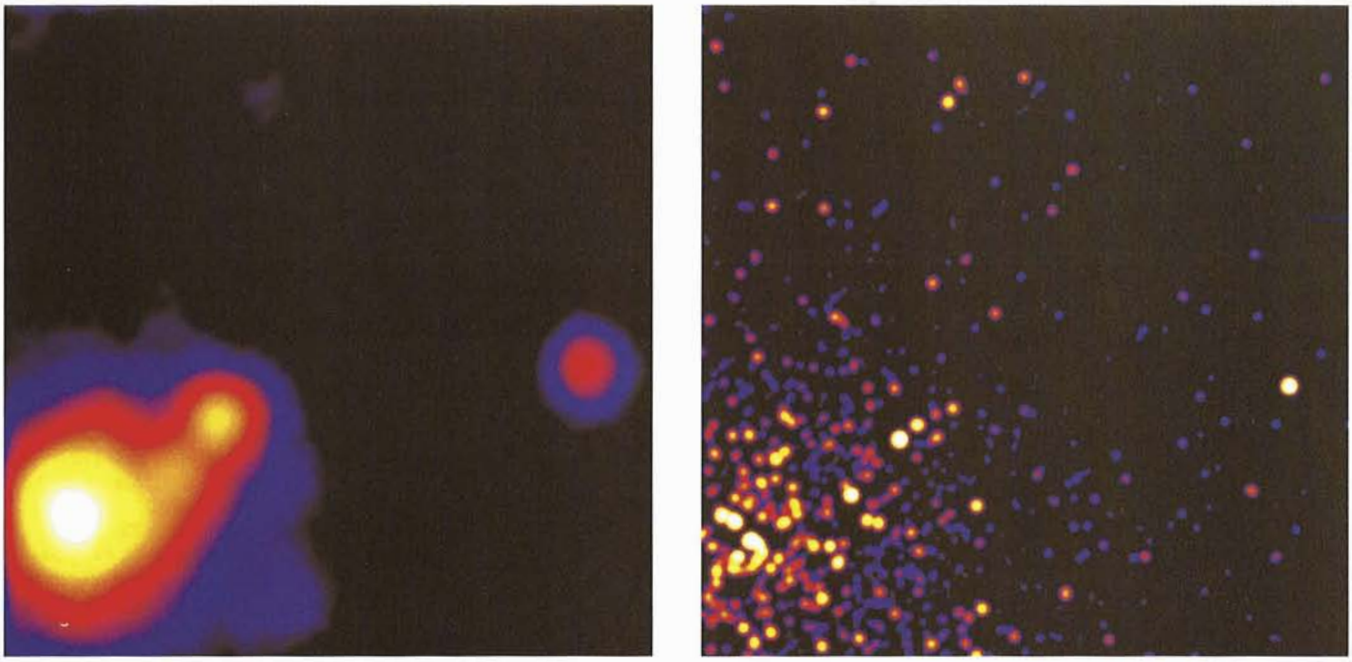

Figure 1: *The-left-hand side shows a short exposure taken in H band with the AO system switched off; the right-hand side shows the same 12."8 × 12."8 (3.2 × 3.2 pc²) field of view in K-band with adaptive optics correction. North is down and east is to the right. Logarithmic scaling has been used.*

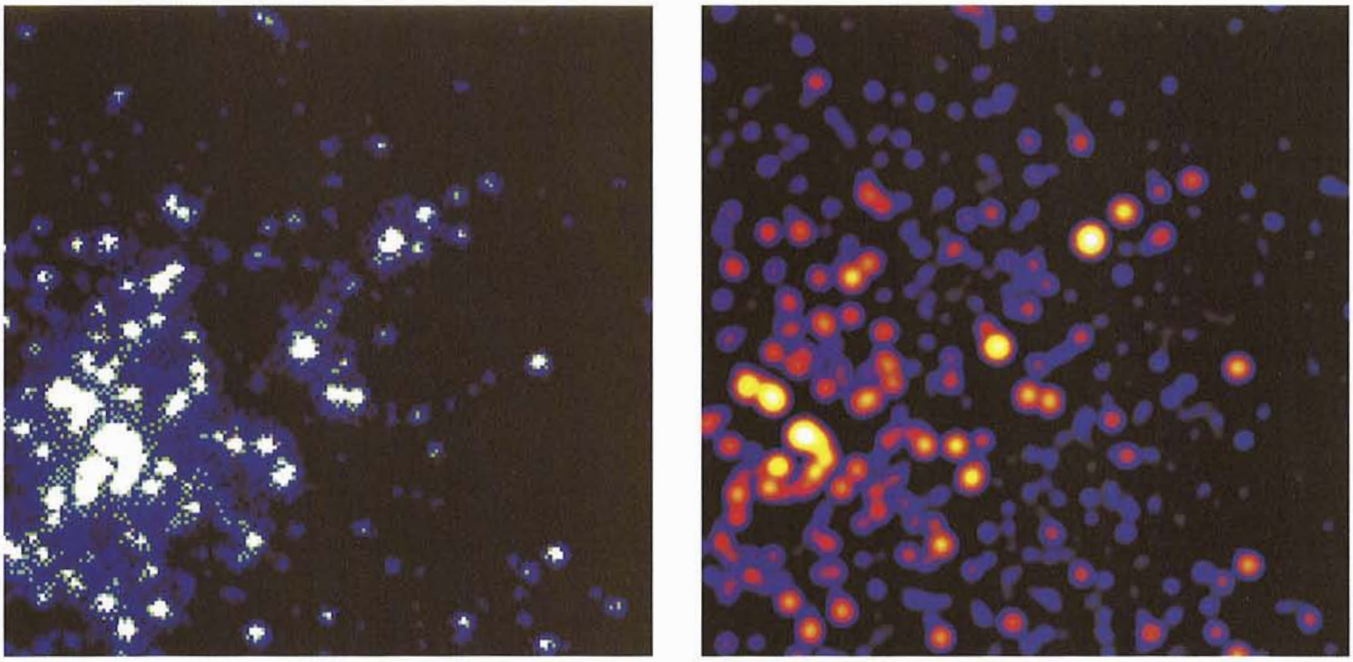

Figure 2: *The central 6."4 × 6."4 around R136 as seen by the HST WF/PC-2 camera (left) and the Come On +/Sharp2 system (right). North is down and east is to the right. The peaks in the HST image are clipped and logarithmic scaling has been used for both images.*

located in the inner 45 pc of this Giant HII region (Campbell et al. 1992). Standard ground-based observations, hindered by atmospheric seeing, showed that the massive core of this stellar cluster (known as R136) consists of three components: R136a, b and c. At one time, R136a was considered to be the most massive star ever known, with about 2000 solar masses (Cassinelli et al. 1981). With ground-based speckle techniques in the visible, Weigelt & Baier (1985) demonstrated that this object consists of at least eight stellar components, thus solving the super-massive star problem. These results have been confirmed by HST observations (Weigelt et al. 1991, Campbell et al. 1992).

The age of the cluster is supposed to lie between 3 and 5 million years, estimated from the presence of massive WN-type Wolf-Rayet stars and the lack of red supergiants. Although none of the stars in R136 is in itself exceptional, the extraordinarily high concentration of O, B and Wolf-Rayet stars represents an ideal, unique starburst laboratory – near enough to be resolved into individual stars and large enough to serve as a typical model of starbursts in distant galaxies.

Observations

The data presented here were taken on December 27, 1994 using the MPE near-infrared camera SHARP2 connected to ESO's adaptive optics system Come On+ on the 3.6-metre telescope on La Silla.

The Sharp2 infrared camera is equipped with a 256 × 256 pixel Rockwell NICMOS3 array detector and is optimised for high-resolution broad-and narrow band imaging in the 1.1–2.5 μm band (Hofmann 1993). The image scale of 0.″05 pixel, results in a total field of view of 12.8 × 12.8 arcseconds and provides Nyquist sampling at wavelengths as short as the J band on the ESO 3.6-m telescope. Wide-band filters provide colour discrimination in J (1.10–1.40 μm), H (1.45–1.85 μm) and K (1.95–2.45 μm) bands. A circular variable filter (CVF) which covers the H and K band with a spectral resolution $\lambda/\Delta\lambda \approx 60$ is also integrated. The total throughput of the optical system, including the quantum efficiency of the detector, is around 50 % in H and K band. The array detector is read out with 4 custom-designed DSP boards permitting integration times from 50 ms up to several minutes per frame.

The Come On+ system (Beuzit et al. 1995) was the first adaptive optics system open to the astronomical community and in its first two years of operation has produced many remarkable results (Léna 1994). A reference source, brighter than approximately 13th magnitude in the V band, is required for wavefront correction. This source must appear unstructured on the wavefront sensor. The central cluster of stars forming R136a itself is sufficiently bright and compact to serve as the wavefront reference in our observations.

We integrated for 190 minutes in the K band under good atmospheric conditions (≈ 1″ seeing). Significant residual triangular coma in the PSF required additional image deconvolution. We used Melnick 34, a bright and isolated star near the edge of our detector, to deconvolve the image. After 5000 iterations of the Lucy-Richardson algorithm (Lucy 1974), the resulting map of delta functions was reconvolved with a Gaussian beam of 0.″12 FWHM, which corresponds to the 3.6-metre telescope's diffraction limit in K.

Results

The left-hand side of Figure 1 shows a short exposure taken in H band with the AO system switched off, while the right-hand side shows our final adaptive optics K-band image. For the first time in this wavelength region, the central stellar minicluster R136a is clearly resolved into several components. The dynamic range between the brightest and the faintest sources is approximately 9 magnitudes. The whole image reveals more than 400 stars above the 3-sigma detection level, the faintest of which are 20th magnitude in K, which corresponds to a lower mass limit of 2–3 $M_\odot$ (Forestini 1993). Assuming a cluster age of 3 million years those stars are still evolving on the pre-main sequence. This detection limit is valid in the outer parts of our field; due to crowding, it is lower in the central region. Transparencies showing the comparison between these images can be obtained from the authors.

Figure 2 displays the central region as previously observed by the refurbished HST (Hunter et al. 1995). Despite the fact that HST's spatial resolution is about twice ours, we see essentially the same sources as observed by Malumuth et al. (1994) plus some additional red objects. Our observations, which also include H- and J-band images, can be combined with HST stellar observations in U, B and V bands in order to minimise photometric errors and estimate the small-scale variations of dust extinction in the dense core of this stellar cluster. A combination of HST and adaptive optics data covers a wide spectral range and enables us to investigate individual stellar types, varying IMF slopes, and the duration of the starburst. The results of this analysis will be presented in a forthcoming issue of *The Messenger.*

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The H_2 Structure of OMC-1: Disruption of a Molecular Cloud

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Introduction

The first detection of infrared quadrupole emission of H_2 in any astronomical object was almost twenty years ago in what is now known as OMC-1 (Gautier et al. 1976). OMC-1 covers an area of approximately 1.5 arcminutes square, located in the giant Orion Molecular Cloud, at a distance of about 450 pc. It contains the much studied Becklin-Neugebauer object and Kleinmann-Low nebula as well as a number of compact