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# Near-Infrared Monitoring of the Carbon Star IRC +10 216: A High Spatial-Resolution Time Sequence of Dust-Shell Evolution

G. Weigelt, T. Blöcker, K.-H. Hofmann, A. Men'shchikov, J.M. Winters

*Max–Planck–Institut für Radioastronomie, 53121 Bonn, Germany*

Y. Balega

*Special Astrophysical Observatory, Nizhnij Arkhyz, 35147, Russia*

The carbon star IRC +10 216 is a long-period Asymptotic Giant Branch (AGB) star suffering from strong stellar winds (several $10^{-5}$ $M_{\odot}$/yr; Loup et al. 1993) which have led to an almost complete obscuration of the star by dust. Due to the high mass-loss rate, long period of $P = 649$ d (Le Bertre 1992), and carbon-rich chemistry of the dust-shell, IRC +10 216 is obviously in a very advanced stage of its AGB evolution. High-resolution near-infrared imaging of IRC +10 216 has revealed that on sub-arcsecond scales (100 mas) its dust shell is clumpy, bipolar, and changing on a time scale of only ~1 yr (Weigelt et al. 1997, 1998, Haniff & Buscher 1998, Osterbart et al. 2000, Tuthill et al. 2000). Since most dust shells around AGB stars are known to be spherically symmetric, whereas most proto-planetary nebulae (PPN) show an axisymmetric geometry (Olofsson 1996), it appears likely that IRC +10 216 has already entered the transition phase to the PPN stage. This suggests that the break of the dust-shell symmetry between the AGB and post-AGB phase already takes place at the end of the AGB evolution.

New bispectrum speckle-interferometry observations of IRC +10 216 were carried out with the Russian 6 m SAO telescope in the $J$, $H$, and $K$ band in Sep. 1999, Oct. 2000, and March 2001 continuing the monitoring of Osterbart et al. (2000) which covers five epochs between 1995 and 1998. Figure 1 shows the reconstructed $K$-band images of the innermost region of IRC +10 216 in 1996, 1998 and 2000. The resolution varies between 82 and 73 mas. The dust shell consists of several compact components, at the beginning within a radius of 200 mas, which steadily change in shape and brightness. For instance, the apparent separation of the two initially brightest components A and B increased from 201 mas in 1996 to 320 mas in 2000. At the same time, component B is fading and has almost disappeared in 2000 whereas the initially faint components C and D have become brighter. In 2001, the intensity level of component C has increased to almost 40% of the peak intensity of component A. Both components appear to have started merging in 2000.

These changes of the dust-shell appearance can be related to changes of the optical depths caused, e.g., by mass-loss variations. The present monitoring, covering more than 3 pulsational periods, shows that the structural variations are not related to the stellar pulsational cycle in a simple way. This is consistent with the predictions of hydrodynamical models that enhanced dust formation takes place on a timescale of several pulsational cycles (Fleischer et al. 1995).

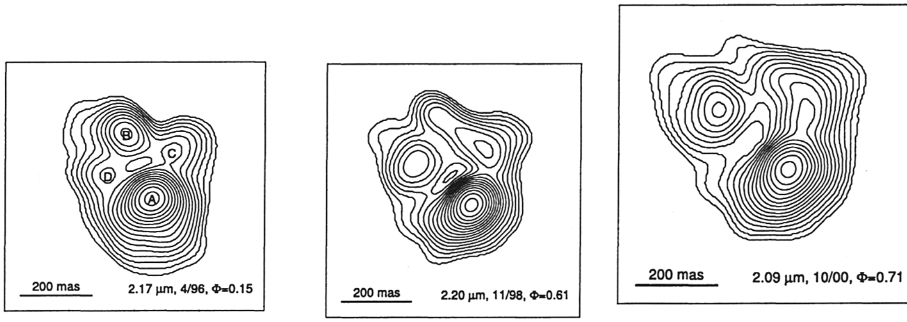


Figure 1. $K$-band speckle reconstructions of IRC +10 216 in 1996 (left), 1998 (middle), and 2000 (right). The resolution is 82 mas, 75 mas, and 73 mas, resp. Contour levels are plotted from 0.1 mag to 3.1 mag relative to the peak intensity in steps of 0.2 mag. North is up and east is to the left.

Our recent two-dimensional radiative transfer modelling (Men'shchikov et al. 2001) has shown that the star is surrounded by an optically thick dust shell with polar cavities of a full opening angle of 36°, which are inclined by 40° pointing with the southern lobe towards the observer. The bright and compact component A is not the direct light from the underlying central star but the southern lobe of this bipolar structure dominated by scattered light. Instead, the carbon star is at the position of the fainter northern component B.

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