Max-Planck-Institut für Radioastronomie

# Diffraction-limited bispectrum speckle interferometry of the carbon star IRC +10 216 with 73 mas resolution:

MAX-PLANCK-GESELLSCHAFT

## The dynamic evolution of the innermost circumstellar environment from 1995 to 2005


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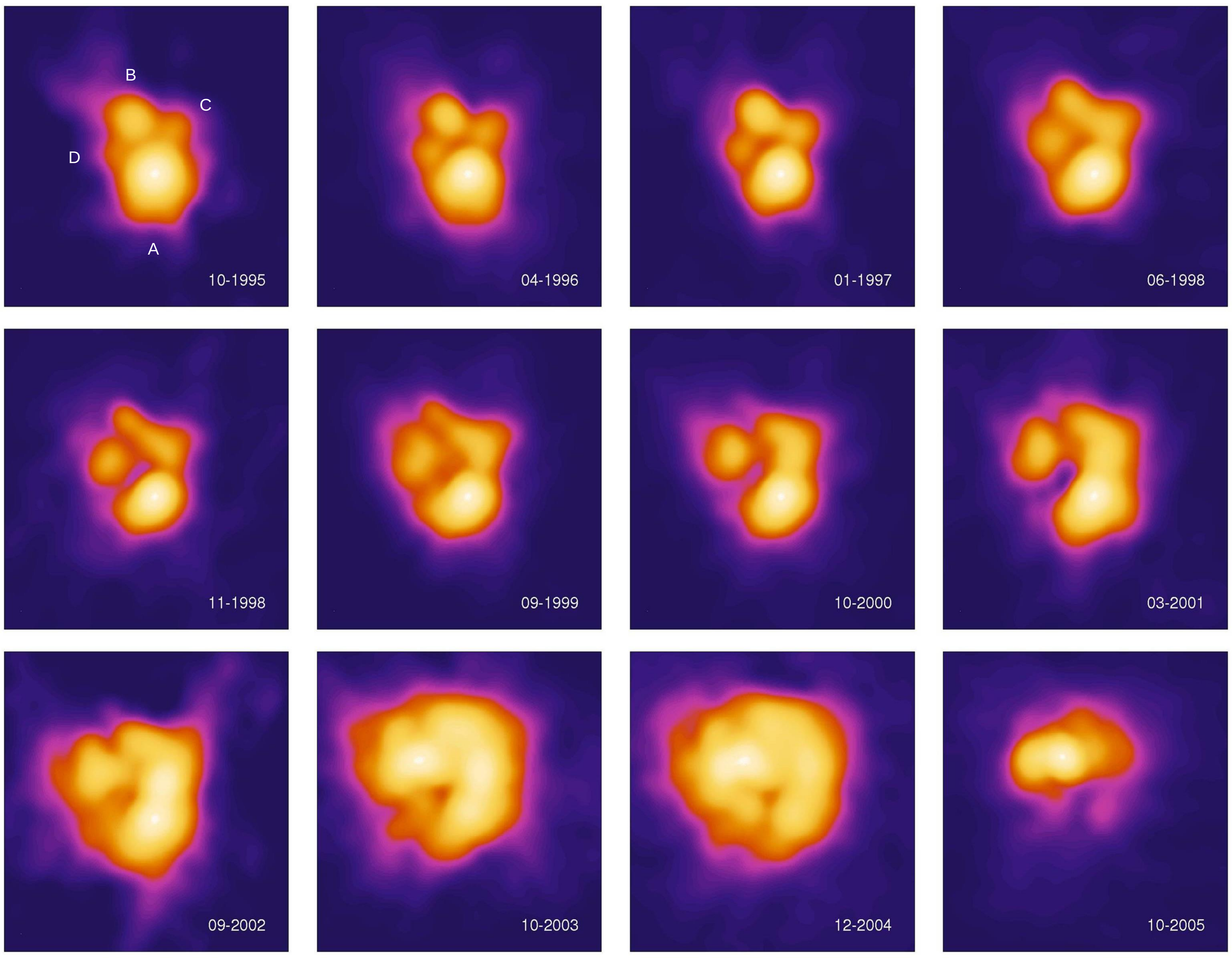


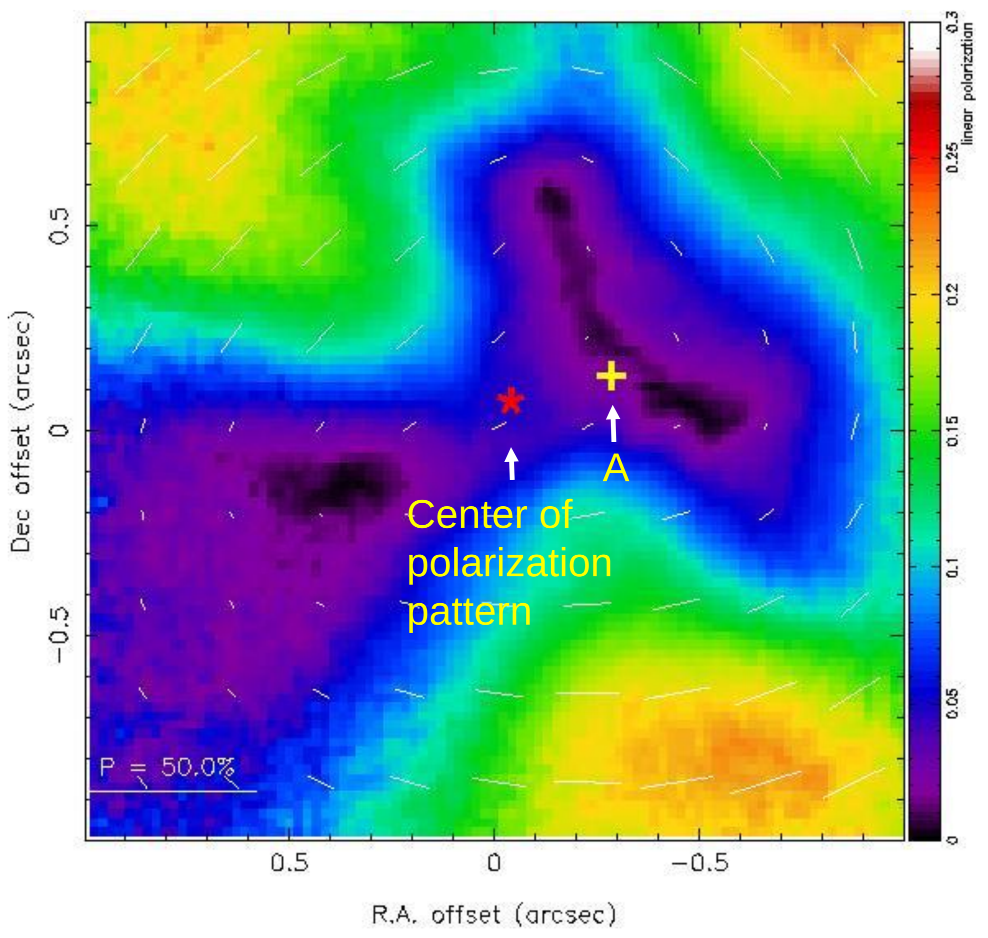


**Introduction.** IRC +10 216 is the nearest carbon star known (distance ~150 pc) and the brightest 12 µm object outside the solar system. A strong stellar wind has led to an almost complete obscuration of the star by dust. The mass-loss rate amounts to 2-5 x$10^{-5}$ solar masses per yr. Based on the high mass-loss rate, the long period of ~649 d, and the carbon-rich chemistry of the dust-shell, IRC +10 216 is obviously in a very advanced stage of its AGB evolution. Interferometric NIR imaging of IRC +10 216 with angular resolutions of better than 100 mas has revealed that its dust shell is clumpy and bipolar, and is changing on a yearly timescale (e.g., Weigelt et al. 1997, 1998, 2002; Men’shchikov et al. 2001, 2002; Haniff & Buscher 1998, Tuthill et al. 2000, 2005; Leao et al. 2006). On larger scales, the envelope of IRC +10 216 appears to be spherically symmetric (Mauron & Huggins 2000). Since most dust shells around AGB stars are known to be spherically symmetric on larger scales, whereas most PPNs appear in axisymmetric geometry (Olofsson 1996), it is likely that IRC +10 216 has already entered the transition phase to PPN. This suggests that the break of symmetry already takes place at the end of the AGB evolution.

**Results.** We present new NIR bispectrum speckle-interferometry monitoring of the carbon star IRC +10 216 obtained between 1999 and 2005 with the 6 m BTA telescope and the 6.5 m MMT (left figure). The achieved J-, H-, and K-band resolutions are 50 mas, 56 mas, and 73 mas, respectively. The total sequence of K-band observations now covers 11 epochs from 1995 to 2005 and shows the dynamic evolution of the inner dust shell. The present observations show that the appearance of the dust shell has considerably changed during the last few years. Four main components within a 200 mas radius can be identified in the K-band images together with a fainter asymmetric nebula. For instance, the apparent separation of the two initially brightest components A and B increased from 191 mas in 1995 to 351 mas in 2001. Simultaneously, component B has been fading and almost disappeared in 2000 whereas the initially faint components C and D became brighter. The changes of the images can be related to changes of the optical depth caused, for instance, by mass-loss variations or new dust condensation in the wind.

Our recent 2-D radiative transfer modeling (Men'shchikov et al. 2001, 2002) suggests that the star is surrounded by an optically thick dust shell with bipolar cavities, with the southern lobe tilted towards the observer, and that IRC +10 216 recently suffered from an higher mass-loss rate of ~$10^{-4}$ solar masses per yr. High-resolution CIAO Subaru polarimetric studies by Murakawa et al. (2005) suggest that the central star (center of the polarization pattern) is located ~ 250 mas east of component A (see right figure; the colors denote the degree of polarization; the blue/pink/black structure represents the polarization disk). Our high-resolution NIR monitoring of the components A, B, C, and D has revealed that the dust shell of IRC +10 216 is rapidly evolving. Detailed 2-D radiative transfer modeling of IRC +10216 (Men’shchikov et al. 2001, 2002) suggests that the observed relative motion of components A and B is not consistent with the outflow of gas and dust at the well-known terminal wind velocity of 15 km/s. The apparent motion with a deprojected velocity of 19 km/s on average and of recently 27 km/s appears to be caused by a displacement of the dust density peak due to dust evaporation in the optically thicker and hotter environment. These results are in very good agreement with Keck observations reported by Tuthill et al. (2000). Such direct observations of the dust-shell evolution offer an ideal opportunity to study the mass-loss process in the late stages of AGB evolution, revealing details of the dust formation process as well as the geometry and clumpiness of the stellar wind. The present monitoring, covering more than 5 pulsation periods, shows that the structural variations are not related to the stellar pulsation 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 pulsation periods.

See: Weigelt et al. 2002 (A&A 392, 131); Men’shchikov et al. 2002 (A&A 392, 921), Murakawa et al. 2005 (A&A 436, 601) and http://www.mpifr-bonn.mpg.de/div/ir-interferometry/