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On the Dusty Envelope of IRC+10216 Illuminated by the Galactic Radiation Field

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Abstract. The shell-like dusty envelope of IRC+10216 has been observed in several bands with the VLT/FORS1 instrument. The collected deep and high resolution images have allowed us to map simultaneously for the first time both the central (inner 10 arcsec) and the most external (up to 3 arcmin) regions of the envelope. From the observed colors and numerical simulations of the nebula, we plan to derive new constraints regarding the galactic radiation field illuminating IRC+10216 and the properties of the dust grains found in its envelope.

1. Introduction

Low and intermediate mass stars lose a large amount of their initial mass when they evolve on the Asymptotic Giant Branch (AGB) and beyond. During these mass-loss events, a huge circumstellar envelope composed by dust grains and molecules is formed. IRC+10216 is the best known example of such evolved stars with optically thick circumstellar envelope.

Martin & Rogers (1987) and Mauron & Huggins (1999, 2000) have revealed that the structure of the IRC+10216 envelope can be studied in visible light. In this spectral domain, the nebula brightness mostly results from galactic ambient light scattered by the dust particles found in the envelope.

The aim of this poster is to present current works done on new deep images of IRC+10216 in U, B and V filters. These data have been collected in order to derive some physical characteristics of its envelope and some constraints about the interstellar radiation field (ISRF) found in its vicinity (see Mauron et al., 2001, for more details).

2. VLT/FORS1 Deep Imaging in the V Band

New V-images of the IRC+10216 envelope have been collected with the VLT/FORS1 focal reducer. These exposures were taken in dark time under very good seeing conditions and photometric sky in January 2000 (see Fig. 1).

As already shown by Mauron & Huggins, the scattered ISRF reveals the presence of material up to very large distance from the central star. The very extended envelope appears fairly round, which is consistent with an isotropic

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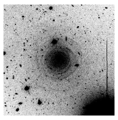

Figure 1. Central part of the VLT/FORS1 image of IRC+10216 in the V-band. The pixel size is 0.2 arcsec. North is up and East is to the left. The field of view is 3.4'×3.4' and the resolution is around 0.4 arcsec. The total observing time of this composite image is 110 min.

galactic radiation field and a spherically symmetric dust shell. On a smaller spatial scale, the envelope consists of a series of discrete and nested multiple shells which origin is still debated.

What appears new in the presented data is the connection between the most outer regions of the nebula (in first approximation of spherical shape) with the central regions where the nebula appears bipolar (see for instance, Tuthill et al., 2000). As shown in Fig. 2 and thanks to the good angular resolution, the bipolar shape of the central region is detected up to ∼15" from the central core and extents far into the spherical outer part of the envelope. The orientation of this bipolar feature which center corresponds to the center of the extended nebula as well as its brighter southern lobe are consistent with previous much higher spatial resolution observations of the IRC+10216 core (Tuthill et al., 2000).

3. Brightness and Colors of the Nebula in the Visible

Several other images have been collected at OHP (France), CFHT (Hawaii) and VLT (Chile) in U, B and V lights. From them, azimuthally averaged brightness profiles have been derived. They are characterized by a "*plateau*" extending up to $\sim 10''$ and by a strong decrease of the brightness beyond, as already shown by Mauron & Huggins (1999) in the B-band. Furthermore, photometric

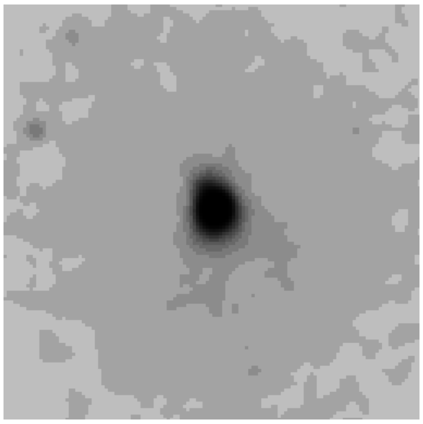

Figure 2. Magnification of the central region of the nebula in the V band, convoluted by a Gaussian with a FWHM of 0.4 arcsec. The field of view is 25"×25", north is up, east to the left.

calibrations allowed us to derive the colors of the nebula in the "*plateau*". Our preliminary estimates are $(U\text{-}B) \sim 0.15 \pm 0.25$ and $(B\text{-}V) \sim 0.50 \pm 0.20$.

4. Modelling of the IRC+10216 Nebula

In order to interpret the observed data, the characteristics of the ISRF and of the dust circumstellar envelope have to be known, and the scattering of light by the dust has to be calculated. Our approach about the ISRF and the envelope parameters is to consider plausible values derived from other studies, and to check whether they can explain our observations.

The assumed characteristics of the envelope of IRC+10216 are taken in Groenewegen (1997), with especially spherical 0.16 μm grains as recommended by him. The properties of the ISRF are found in Mathis et al. (1983) and Mattila (1980).

With these sets of parameters, we have solved the radiative transfer equations in the dusty nebula by a Monte-Carlo technique. Synthetic azimuthally averaged brightness profiles are then obtained and compared to the observed ones.

5. Preliminary Results

From the comparison of the observed and synthetic brightness profiles, our preliminary results indicate that the observed colors of the nebula should be rather well reproduced by large grains. Small grains indeed lead to a synthetic nebula much too blue compared to the observations. An ISRF as modelled by Mattila (1980) seems to be consistent with our data in terms of colors but a fainter ISRF flux is favoured in all wavelengths, supporting one of the suggestions of Martin and Rogers (1987). There is also a substantial discrepancy between model and observations concerning the half-intensity radius of the nebula, as shown in

Fig.3, and this suggests that scattering properties of circumstellar amorphous carbon grains could not be well modelled in the visible range. More details and other results will be presented in Mauron et al. (2001).

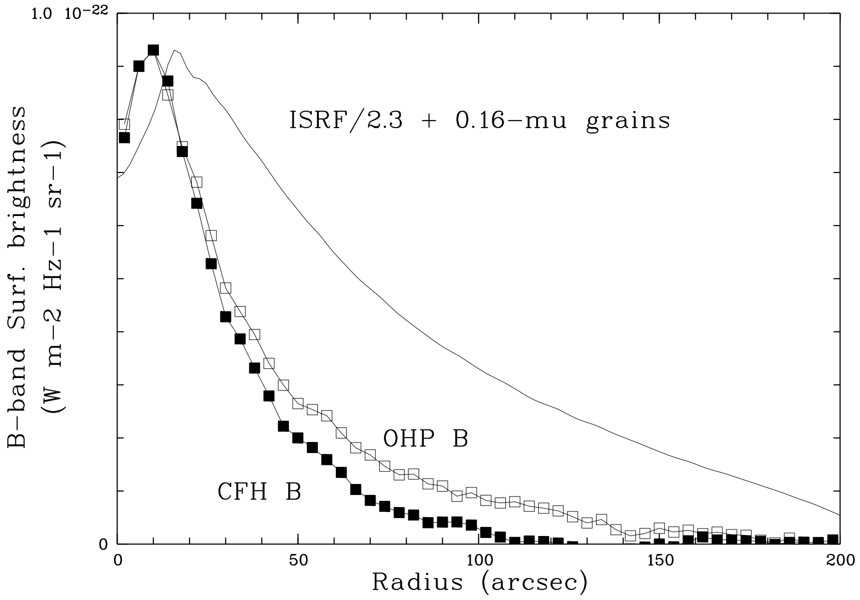

Figure 3. Surface brightness profiles of the IRC+10216 nebula in B-light. The data points are from OHP and CFHT observations. A model calculated with 0.16μm amorphous carbon grains and a galactic ambient field 2.3 fainter than in the solar vicinity is also shown. Note the large discrepancy concerning the half-maximum radius.

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References

Groenewegen M.A.C., 1997, A&A 317,503,

Martin P.G., Rogers C., 1987, ApJ 322, 374

Mathis J.S., Mezger P.G., Panagia N., 1983, A&A 128, 212

Mattila K., 1980, A&AS 39, 53

Mauron N., Huggins P. J., 1999, A&A 349, 203

Mauron N., Huggins P. J., 2000, A&A 357, 707

Mauron N., de Laverny P., Lopez B., 2001, A&A in preparation

Tuthill P.G., Monnier J.D., Danchi W.C., Lopez B., 2000, ApJ 543, 384