THE CIRCUMSTELLAR ENVIRONMENT OF MWC297: ISO RESULTS AND FIRST EXPECTATIONS

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ABSTRACT

The ISO SWS and LWS full grating spectra of the Herbig Be star MWC297 are presented. The spectra are dominated by a strong continuum; in addition, in the SWS range (2.3-45μm), emission lines from the HI recombination series, PAH emission and absorption by solid CO₂, H₂O, and silicates have been observed while in the LWS spectrum (43-197μm) [OI] and [CII] fine structure lines have been detected.

The NIR-FIR data have been combined with ground based photometry to derive the spectral energy distribution (SED) from optical to radio wavelengths. The observed SED has been compared with the SED’s computed with a spherical dusty envelope model parametrized by a density and temperature law in order to probe if such a circumstellar matter distribution is compatible with the observations, deriving also suitable values for the spectral type, the extinction and the distance. Consistent determination of the extinction and estimates of both the source mass loss rate and the size of the emitting ionized region have been derived by the analysis of the HI recombination lines of the Brackett, Pfund and Humphreys series observed by ISO together with Paschen and Brackett lines observed from the ground.

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Key words: Stars: individual: MWC297 – Stars: mass-loss – circumstellar matter

1. INTRODUCTION

The Herbig Ae/Be (HAEBE) star MWC297 has originally been classified as a B0 pre-Main Sequence star (Bergen et al. 1988) positioned at a distance of 450 pc (Cantò et al. 1984), but Drew et al. (1997) revised this view attributing to this object a spectral type B1.5, a distance of 250 pc and a later evolutionary state. KAO images by Di Francesco et al. (1998) show the presence of a quite extended circumstellar region, whose size is ~60′′ × 50′′, with a total flux of 1100±540 Jy at 50μm and 1300±640 Jy at 100 μm.

In this contribution we analyse the NIR-FIR spectra of MWC297, provided by the two spectrometers on board the Infrared Space Observatory (ISO) satellite in order to derive the distribution and the physical parameters of circumstellar matter. However, the large spatial resolution of the ISO spectrometers, in particular at FIR wavelengths (~80′′), are not good enough to directly resolve the morphology of the circumstellar envelope around HAEBE stars; on the contrary, the higher spatial resolution (9.4 arcsec) of the Photoconductor Array Camera and Spectrometer (PACS, spectral range 60 - 210 μm) on board the FIRST satellite, will be suitable for this purpose. We will show the capabilities of the PACS instrument in answering some of the still open questions that we address in our analysis.

2. ISO OBSERVATIONS

MWC297 (RA(2000): 18h 27m 39.5s; DEC(2000): -3° 49’ 52.1’’) was observed with the two spectrometers, the Short Wavelength Spectrometer (SWS, de Graauw et al. 1996) and the Long Wavelength Spectrometer (LWS, Clegg et al. 1996), on board ISO, during revolution 708. The spectra (SWS: 2.3-45μm, LWS: 43-197μm) have been carried out with the AOT01 full grating scan mode, corresponding to a resolution from 250 to 600 for SWS and ~200 for LWS. Raw data have been processed with the OLP 7 and 9 for SWS and LWS respectively. An additional analysis has been performed in order to remove glitches, average the different spectral scans and remove the fringes present in the LWS long-wavelength range.

The spectra are dominated by a strong continuum with superimposed several emission lines and features both in emission and in absorption (fig. 1 and 2). In particular, in the SWS range we detect 23 emission lines from the Brackett, Pfund and Humphreys HI recombination series, PAH emission at 3.53, 6.22, 13.56 and 14.21 μm, silicate broad band absorption at 9.7 and 16.4 μm and absorption features at 2.96 and 4.27 μm by CO₂ and H₂O ice respectively. In the LWS spectrum, fine structure lines from [OI]
at 63.17 and 145.53 µm plus the [CII] at 157.80 µm have been detected (Lorenzetti et al. 1999).

3. CONTINUUM SPECTRUM

From the inspection of fig. 1, beam effects due to the extent of the emitting region are clearly evident since portions of the spectrum observed with different beamsizes do not overlap.

The spectral energy distribution (SED) derived from ISO data and complemented with photometric measurements from optical to radio wavelengths have been compared with a spherical dusty model (see Pezzuto et al. (1997)) for a description of the model and references to photometric data). The temperature and density distributions of the circumstellar envelope are parametrized by a radial power law with index q and p, respectively.

By fitting the observed SED (fig. 3), the following parameters have been derived: q=0.5, p=1.1, SpT=B2, distance=280 pc and A_V=7.5 mag. The spectral type and the distance estimates are in agreement with the values given by Drew et al. (1997). We note that in the SWS spectral range the model predicts a flux density higher than the observed value, this can be ascribed to the extendness of the source which is probably larger than the SWS beams as can be inferred from the inspection of the ISO spectra (see fig. 1) in which a sharp rise in the flux density is observed whenever the beam aperture increases (i.e. at 27, 29, 45 µm). Moreover, the SWS beam at 45µm (20''×33'') is smaller than the size of the emitting region at 50 µm measured by Di Francesco et al. (1998) ((57±13)''×(46±15)'').

4. HI RECOMBINATION LINES

The observed HI recombination lines have been compared with a wind model (see Benedettini et al. 1998) which considers a spherical gas envelope, fully ionized up to a distance R from the central star, with a constant rate of mass loss. The gas is assumed to be in LTE condition and
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5. The anomalous [OI] line ratio

The ratio between the two [OI] lines \([\text{[OI]63}\mu m]/[\text{[OI]145}\mu m] = 1.8 \pm 0.2\) is extremely low with respect to the model predictions of both PDR (Kaufman et al. 1999) and shock (Hollenbach & McKee 1989) which are never smaller than 10. Ratios smaller than 10 have been found also in other YSOs observed by ISO (Saraceno et al. 1998) but the value measured in MWC297 is the lowest. Such a ratio could be accounted for if both lines were optically thick and arising from a gas at \(T \sim 80\) K, but this would imply a column density \(N_H \gg 5 \times 10^{22} \) cm\(^{-2}\) contrasting with our determination of \(N_H \sim 5 \times 10^{22} \) cm\(^{-2}\), derived from the Av value. Alternatively, the observed ratio could be interpreted as due to strong absorption of the [OI]63\(\mu m\) line by cold (~100 K) OI present along the line of sight.

6. FIRST expectations

The better spatial resolution of PACS (9.4 arcsec) with respect to the ISO spectrometers will be crucial to solve some of the open problems which have been highlighted.
above; these considerations can be applicable more generally, to the whole class of HAEBE stars.

1. By using the PACS photometric capability (FOV = 3.5$\times$1.75 arcmin$^2$) it will be possible to spatially resolve the circumstellar envelope around the HAEBE stars and to derive the physical parameters of the matter distribution. As an example in fig. 5 we show how the extended spherical emission foreseen by our model is expected to be imaged by the PACS arrays at 75, 110 and 170 $\mu$m.

2. By using the PACS spectroscopic capability a map of 47$''$×47$''$ in both the 63$\mu$m and 145$\mu$m [OI] lines can be used to probe their ratio in order to verify if the anomalous value measured by ISO is locally generated in each spatial sample or results from averaged contributions encompassed by the larger ISO sampling.

REFERENCES

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