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Bispectrum speckle interferometry of the B[e] star MWC 349A

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Abstract. We present the results of bispectrum speckle interferometry of the B[e] star MWC 349A obtained with the SAO 6 m telescope. Our diffraction-limited *J-, H-*, and *K*-band images (resolutions 43–74 mas) suggest the star is surrounded by a circumstellar disk seen almost edge-on. The observed visibility shape is consistent with a two-component elliptical disk model, probably corresponding to the gaseous and dusty components of the disk. We show that the classification of the object as a pre-main-sequence star or a young planetary nebula is problematic. An analysis of the uncertainties in the basic parameter determination lead us to the conclusion that MWC 349A is probably either a B[e] supergiant or a binary system, in which the B[e]-companion dominates the observed properties.

Key words. techniques: image processing —— stars: emission-line – stars: individual: MWC 349A

1. Introduction

MWC 349 consists of two apparently close (the angular distance is 2.4 arcsec) objects: MWC 349A, which exhibits a strong emission-line spectrum and IR-excess, and MWC 349B, a weak emission-line source which is ∼40% fainter than MWC 349A in the optical region (Cohen et al. 1985, hereafter C85). C85 argued that MWC 349A and MWC 349B are a physical pair, as they are connected by an arc of emitting matter, and estimated the distance (1.2 kpc) toward it based on the spectral type and luminosity of MWC 349B (B0 III and $M_V = -5.0$ mag, respectively). However, Meyer et al. (2002) found that the A and B components have a different level of interstellar polarization, suggesting that they are not connected to each other and that MWC 349A could be a member of Cyg OB2. In this paper we concentrate on MWC 349A and use MWC 349B only as a reference star for our observations.

MWC 349A is a peculiar stellar object with one of the strongest emission-line spectra ever observed. It is located in the southern part of the Cyg OB2 association, a heavily reddened stellar cluster at a distance of 1.7 kpc (e.g., Knödlseder 2000). The object does not show any photospheric lines in its spectrum (Andrillat, Jaschek, & Jaschek 1996), although the presence of strong He I emission lines indicates a high temperature of the underlying source. In most of the studies devoted to the nature of MWC 349A its spectral type is estimated as late O (e.g., Hartmann, Jaffe, & Huchra 1980). The co-existence of forbidden emission lines in the optical spectrum and a near-IR excess brought MWC 349 into the group of B[e] stars (Allen & Swings 1976). On the other hand, MWC 349A is considered to be a pre-main-sequence object because of the surrounding nebula, which is formed by an optically-thick bipolar outflow seen at radio wavelengths (Olnon 1975). The bipolar structure of the nebula suggests that the stellar core is surrounded by a disk, whose presence is inferred from a high level of polarization (Elvius 1974, Zickgraf & Schulte-Ladbeck 1989, Yudin 1996; Meyer, Nordsieck, & Hoffman 2002) and double-peaked emission-line profiles (Hartmann et al. 1980). MWC 349A also shows maser and laser line emission in the IR and radio spectral regions, which makes it rather unique among similar sources (see Gordon et al. 2001 for a recent update).

Since MWC 349A is a distant object, observations with high spatial resolution are crucial for revealing its nature. So far results of only a few high-resolution near-IR observations have been published. Leinert (1986) marginally resolved the IR source and found it elongated with a gaussian FWHM of the brightness distribution of 85 ± 19 mas in the east-west direction at L′ and 38 ± 18 mas in the north-south direction at K. The highest resolution measurements were presented by Danchi, Tuthill, & Monnier

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Table 1. Observational parameters. λ_c is the central wavelength and $\Delta\lambda$ the FWHM bandwidth of the filters. T denotes the exposure time per frame and N is the number of frames. S denotes the seeing (FWHM) and p is the pixel size.

| λ_c [μm]	$\Delta\lambda$ [μm]	T [ms]	N	S ["]	p [mas]
1.24	0.14	120	695	0.7	13.30
1.65	0.32	80	383	0.9	20.08
2.12	0.21	30	855	1.2	26.95
2.09	0.02	160	820	0.7	26.66

Table 2. Results of two-dimensional elliptical uniform-disk fits to the visibilities of MWC 349A for a fit range up to the telescope cut-off frequency (see discussion on the fit range in the text).

Filter [μm]	Major Axis [diameter, mas]	Axial Ratio	Position Angle [deg]
1.24/0.14	47.5 ± 2.7	0.75 ± 0.04	109.7 ± 5.0
1.65/0.32	56.2 ± 1.8	0.70 ± 0.08	100.9 ± 2.0
2.12/0.21	65.0 ± 2.7	0.63 ± 0.04	101.4 ± 2.0
2.09/0.02	62.5 ± 2.7	0.62 ± 0.04	105.2 ± 2.0

(2001). These authors showed that the IR source can be fitted by uniform ellipses with major axes of 36 ± 2 mas at 1.65 μm, 47 ± 2 mas at 2.25 μm and 62 ± 1 mas at 3.08 μm, axial ratios of ~ 0.5, and a position angle of $100^{\circ} \pm 3^{\circ}$. Under a flat disk approximation, Danchi et al. estimated the inclination angle of the disk plane to the line of sight to be $\sim 21^{\circ}$. They also found the observed disk sizes at the above wavelengths consistent with the theoretical predictions for the inner and outer dimensions of photoevaporating accretion disks around young stars reported by Hollenbach et al. (1994).

To verify the results by Danchi et al. (2001) and to extend the spatial information toward shorter wavelengths, we obtained new speckle interferometric observations of MWC 349A in J, H, and K broadband filters and a narrowband filter at 2.09 μm. Our results are presented in Sect. 2. Additionally, we review the existing information about the object, as its nature and evolutionary state remain uncertain. Most of the investigators focus on details of the circumstellar (CS) structures (mainly on the disk) in efforts to interpret the observed features, while properties of the illuminating source are only vaguely known. In Sect. 3 we re-estimate physical parameters of the object and examine existing hypotheses on its nature. In Sect. 4 we consider the reliability of the adopted parameters and summarize our findings in Sect. 5.

2. Observations

The speckle interferograms of MWC 349A were obtained with the Russian 6 m telescope of the Special Astrophysical Observatory (SAO) on October 28, 2001 and November 1, 2001. The data were taken with our HAWAII speckle camera through interference filters with center wavelengths/bandwidths of 1.24μm/0.14μm, 1.65μm/0.32μm, 2.12μm/0.21μm and 2.09μm/0.02μm. The simultaneously recorded speckle interferograms of the unresolved star MWC 349B were used for the compensation of the atmospheric speckle transfer function. The observational parameters are summarized in Table 1.

Diffraction-limited images of MWC 349A were reconstructed from the speckle interferograms using the bispectrum speckle interferometry method (Weigelt 1977;

Lohmann et al. 1983; Hofmann & Weigelt 1986) and the building block method (Hofmann & Weigelt 1993). The modulus of the object Fourier transform (visibility function) was determined with the speckle interferometry method (Labeyrie 1970). The reconstructed visibilities and diffraction-limited images are presented in Fig. 1.

The results of two-dimensional elliptical uniform-disk fits to the visibilities are summarized in Table 2. Our visibilities are in very good agreement with the visibilities presented by Danchi et al. (2001). However, the diameters of the best-fitting elliptical uniform-disk models presented in Table 2 are different from those derived by Danchi et al. (2001). This difference is not surprising because the elliptical uniform-disk model does not match well the shape of the observed visibilities, and hence a different fit range (due to the different telescope diameters) results in different disk diameters. For example, larger diameters (J: 78 mas, H: 77 mas, K: 79 mas) are obtained if a fit range of up to only 6 cycles/arcsec is chosen.

The shape of the observed visibilities is more complex than that of a simple Gaussian or uniform-disk model. At spatial frequencies of ~ 6 cycles/arcsec the steepness of all visibility curves decreases considerably. This structure suggests a two-component visibility model. Fig. 2 shows best-fitting two-component models, consisting of two Gaussian functions, fitted to the cuts through the short and long axes of the two-dimensional visibilities of MWC 349A. Table 3 summarizes the results of all two-component fits (short and long visibility axes). The visibilities along the short axis up to ~ 6 cycles/arcsec correspond to an extended object with a FWHM Gaussian fit diameter of 94–119 mas, whereas the visibilities (along the short axis) at higher spatial frequencies correspond to the second, more compact component with an angular diameter of only 22–27 mas. This two-component structure can be recognized because of the small errors of the visibilities. These errors are small because the speckle interferograms of the object (MWC 349A) and of the reference star (MWC 349B), at a separation of only 2.4 arcsec, were recorded simultaneously. This has the advantage that the object and the reference star speckle interferograms were recorded under identical seeing conditions and therefore calibration errors of the speckle transfer function are avoided.
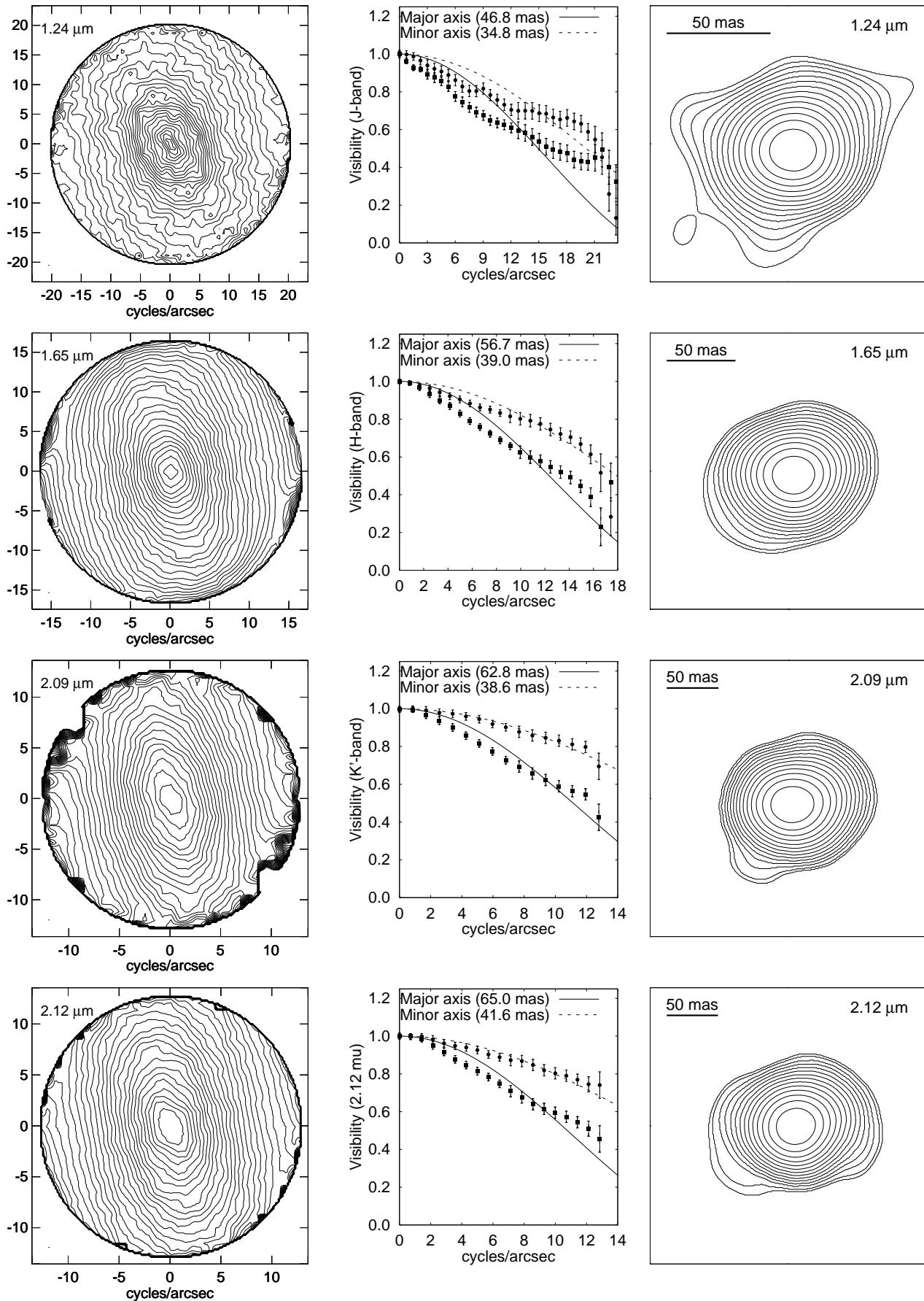
Fig. 1. Left column: two-dimensional visibilities. Middle column: cuts through the long and short axis of the visibilities and the visibilities of the best-fitting two-dimensional elliptical uniform-disk models fitted up to the telescope cut-off frequency. Right column: images of MWC 349A reconstructed by bispectrum speckle interferometry. The contours are plotted in steps of 0.3 mag (from 0.3 mag to 4.2 mag of peak intensity).
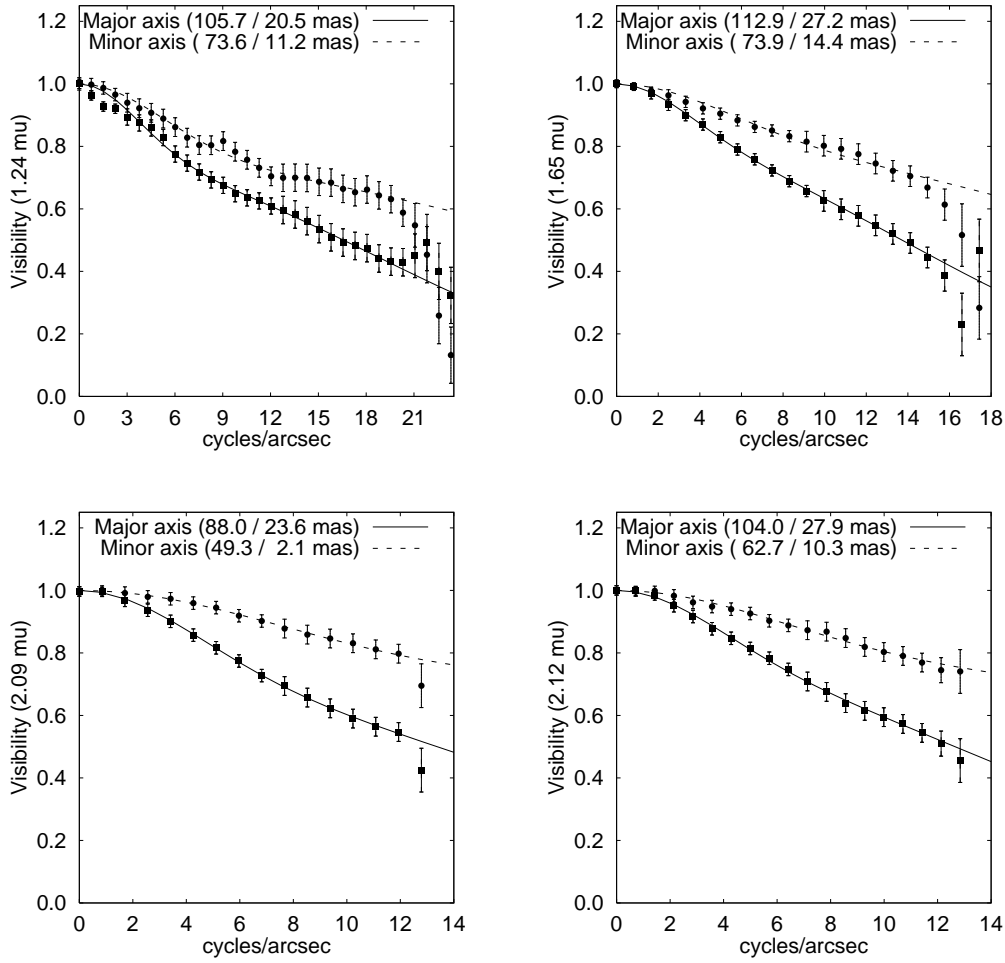
Fig. 2. The visibilities of the best-fitting two-component visibility models consisting of two Gaussian functions fitted to the cuts through the short and long axes of the measured visibilities (corresponding to the major and minor axes of the Gaussian disk in image space). The fit range chosen is up to the telescope cut-off frequency. The numbers in parenthesis are the FWHM diameters of the large/small component of the two-component model.

Table 3. Two-component fit diameters: Results of one-dimensional fits of two-component models consisting of two centered Gaussian functions to the cuts through the short and long axes of the MWC 349A visibilities.

Filter [μm]	FWHM [mas]: Large Component Major Axis	FWHM [mas]: Large Component Minor Axis	FWHM [mas]: Small Component Major Axis	FWHM [mas]: Small Component Minor Axis	Brightness Ratio Large/Small Component
1.24/0.14	118.7 ± 19.6	73.6 ± 14.0	21.8 ± 1.0	12.4 ± 2.0	0.32 ± 0.03
1.65/0.32	115.7 ± 7.6	68.8 ± 7.4	26.9 ± 3.0	15.4 ± 2.3	0.22 ± 0.02
2.12/0.21	95.8 ± 11.7	58.1 ± 7.3	25.1 ± 4.6	9.7 ± 6.1	0.38 ± 0.16
2.09/0.02	93.7 ± 8.6	49.4 ± 7.0	25.6 ± 3.1	13.5 ± 8.5	0.34 ± 0.10

An interpretation of the IR images of MWC 349A in terms of a CS disk seen nearly edge-on has been presented in detail by Danchi et al. (2001). They have shown that the elongated IR source resolved in MWC 349A can be fitted with a viscous accretion disk, which possibly has a hole inside and is illuminated by a hot central star. However, a viscous excretion disk also meets these criteria (e.g., Lee et al. 1991 and Morris 1981). It is therefore impossible to distinguish unambiguously between these two models without considering the nature of the central source. This analysis is presented in Sect. 3.

3. Possible nature of MWC 349A

Three alternative points of view on the nature of MWC 349A and, correspondingly, three different classifications of the object have been considered:

1. a Herbig Be star accreting material from a disk (Thompson et al. 1977)
2. an evolved B[e] supergiant surrounded by an excretion disk (Hartmann et al. 1980)
3. a young planetary nebula (Ciatti, D′Odorico, & Mammano 1974)

All these hypotheses are based on similarities between some of the observational features of MWC 349A and those of the corresponding types of objects. In order to make the right choice, one first needs to constrain the physical parameters of the stellar source illuminating the CS material, since these parameters are the basis for calculations of the physical conditions in the CS environments. Let us review the existing information about the underlying stellar source and summarize the constraints on its parameters.

The effective temperature ($T_{eff} \sim 35000\,K$) of MWC 349A was estimated by means of the Zanstra method, assuming that the CS dust is external to the gas (Hartmann et al. 1980), and from the absence of He II emission lines in the spectrum. The latter finding is usually credited to Felli et al. (1985), who used the LTE Kurucz (1979) model atmospheres to calculate the He I photoionization. However, later Schmutz et al. (1991), in their study of an Ofpe/WN9 star R84 with a weak He II line emission, showed the importance of a NLTE approach and derived an upper limit of $T_{eff} \sim 28000\,K$ for the presence of He II lines in emission. On the other hand, strong He I emission lines, such as those observed in the spectrum of MWC 349A, are usually seen only in emission-line objects with spectral types earlier than B2, constraining a lower limit for the T_{eff} at $\sim 20000\,K$ (e.g., Miroshnichenko et al. 1998a). Thus, the T_{eff} of MWC 349A more likely corresponds to a spectral type of B0–B1. The same conclusion has also been drawn for B[e] objects with optical spectra similar to those of MWC 349A (e.g., CI Cam, Hynes et al. 2002). We should note here that UV observations are needed to better constrain T_{eff} for such a hot object. So far it seems that only one observation of MWC 349A has been obtained in this spectral range: an IUE large-aperture short-wavelength spectrum, which is rather noisy and contains a contribution from MWC 349B.

In order to estimate the luminosity of MWC 349A, one needs values of its optical brightness, interstellar (IS) and CS extinction, and distance. From the spectrophotometric data obtained in 1976 and 1979, C85 derived the continuum $V=13.96\,mag$. At that time MWC 349A, which was found significantly variable ($\Delta R \sim 1.5\,mag$, Jorgenson, Kogan, & Strelnitski 2000), had nearly the mean brightness level.

The most difficult task is the extinction determination. Since no photospheric lines are seen in the spectrum, a certain amount of the CS continuum due to free-free and free-bound radiation distorts the star's spectral energy distribution (SED). It is unclear if the CS dust affects the SED, because the CS disk plane, where the dust seems to be located, is inclined ~ 20 degrees to the line of sight. Therefore, if the disk is flat or mildly flared, the dust may not contribute to the CS extinction. C85 estimated the IS extinction to be between $A_V=8.8\pm0.1\,mag$ to $9.9\pm0.4\,mag$, depending on the assumption of whether the object's SED is affected by the CS matter alone or not. This approach, however, provides no information about the above mentioned CS contribution to the object's brightness. At the same time, both mentioned A_V estimates give effectively the same result for the extinction-free brightness. The smaller A_V corresponds to the accretion disk veiling, which may well be of the order of 1 mag, i.e. roughly the difference with the other A_V estimate, based on the normal star SED. Thus, we can safely adopt a mean brightness of $V=14\,mag$ and $A_V=9.9\,mag$ for MWC 349A. More precise estimates require a self-consistent modeling of both the continuum SED and the emission-line spectrum.

There are two different estimates of the distance to MWC 349A. One assumes that the object belongs to Cyg OB2, whose distance is 1.7 kpc (Knödlseder 2000), while the other one is based on the physical association of MWC 349 A and B and an assumption that MWC 349B is a normal B0 III star (1.2 kpc, C85). According to Neckel & Klare (1980), the IS extinction in the direction of MWC 349 increases rapidly with distance, reaching 4–5 mag at $D=1$–1.5 kpc. Analysing the 2MASS near-IR survey data, Knödlseder (2000) found that for the objects belonging to Cyg OB2 (a region centered at R.A.$=20^h33^m10^s$ and Dec.$=+41°12′$ (J2000) with a radius of 1.05 degrees, which includes the position of MWC 349) the IS extinction varies from 5 to 20 mag. Altogether, these facts suggest that MWC 349 is most likely a member of Cyg OB2 at $D=1.7\,kpc$.

Combining the adopted values, one can estimate the absolute magnitude of MWC 349A to be $M_V = -7\pm1\,mag$ (close to that adopted by Hartmann et al. 1980 after rescaling for the distance difference, $-6.7\,mag$). From the above result for the T_{eff}, a bolometric correction of BC$=-2.5\pm0.4\,mag$ (Miroshnichenko 1998b) can be deduced. Considering all possible sources of uncertainty (V-magnitude, A_V, distance, and BC), we derive a luminosity of $\log L/L_{\odot} = 5.7\pm1.0$. The luminosity value is the most crucial parameter for distinguishing between the possible models for this puzzling object. The resulting error is assumed to be rather large, but nevertheless of no influence on our further analysis. In the next sections we consider all the hypotheses about the nature and evolutionary state of MWC 349A mentioned above.

3.1. Pre-main-sequence star

According to the theory of pre-main-sequence evolution, only stars with initial masses of ≤ 8–$10\ M_\odot$ can be observed in the optical region before they enter the main-sequence evolutionary phase (Palla & Stahler 1993). The mass of MWC 349A, estimated by Ponomarev, Smith, & Strelnitski (1994) from the Keplerian velocities of the CS gas ($M_* = 26\,(D/1.2\ \mathrm{kpc})\ M_\odot$), is out of the above range by far. Also the object's luminosity, estimated above, is at least an order of magnitude higher than those observed in Herbig Be stars and those calculated by Palla & Stahler (1993) for pre-main-sequence models, even with the highest protostellar accretion rate of $10^{-4}\ M_\odot\,\mathrm{yr}^{-1}$. Furthermore, a few known pre-main-sequence Herbig Be stars of early-B subtypes (such as MWC 1080 and R Mon) display much stronger far-IR excesses, due to the radiation of the cold dust from the protostellar cloud, than that observed in MWC 349A. The IRAS and ISO (Thum et al. 1998) fluxes decrease rather steeply longward of $\sim 25\mu m$, indicating a lack of cold dust in the immediate surroundings of the object. The presence of the secondary component in pre-main-sequence stars does not affect the outer regions of the CS envelope, since almost all early B-type Herbig Be stars are known to be binaries (e.g., Leinert, Richichi, & Haas 1997).

In principle, the cold dust may be destroyed by a strong diffuse UV radiation field of hot stars in Cyg OB2, which contains more than 100 O-type stars and is considered to be a young globular cluster (Knödlseder 2000). However, if MWC 349A does belong to Cyg OB2, it is hardly a pre-main-sequence object, because many cluster members are evidently more evolved (a few WR stars and LBV candidates, as well as ~100 O-type stars, are known in Cyg OB2) and seem to have been born at roughly the same time. It also seems unlikely that MWC 349A is much closer to us, because different data, such as photometry and spectroscopy (C85) as well as polarimetry (Meyer et al. 2002), indicate the presence of a large IS reddening inconsistent with a distance less than 1 kpc.

Another characteristic, which needs to be considered here, is the shape of the object's spectrum in the $10\,\mu m$ region. The features seen in this region are indicative of the chemical composition and/or the optical depth of the CS dust. The spectrum of MWC 349A is essentially featureless (except for the line emission) between 8 and $13\,\mu m$ (e.g. Rinehart, Houk, & Smith 1999). This suggests either that the optical depth of the dust is large or that the CS dust is mostly composed of amorphous carbon. The latter is not consistent with the very young age of the object, as the carbon-rich dust is usually observed around evolved objects, which create the dust from the material processed in the stellar interiors. From all of the above, we can conclude that MWC 349A is unlikely to be a pre-main-sequence object.

3.2. Young planetary nebula

Some of the observed features of MWC 349A are similar to those of post-AGB stars, which evolve toward the planetary nebula phase (for example, the compact nebulae). However, such stars produce dust only during the AGB phase. Later the dust moves slowly further away from the star, becomes colder, and radiates only in the far-IR region of the spectrum. This is not the case for MWC 349A. Additionally, the derived luminosity of the object exceeds those of the most massive proto-planetary nebulae by at least an order of magnitude (e.g. Blöcker 1995). Thus, it seems possible to rule out the suggestion that MWC 349A is a post-AGB object.

3.3. B[e] supergiant

The adopted T_{eff} and luminosity of MWC 349A (log $L/L_\odot \approx 5.7 \pm 1.0$), along with the strong emission-line spectrum and the SED shape, make it very similar to B[e] supergiants, a type of evolved star first discovered in the Magellanic Clouds (Zickgraf et al. 1986). Their properties include the co-existence of broad emission lines of high-excitation species (e.g. C IV) with P Cyg-type profiles in the UV region and much stronger single- or double-peaked line profiles of low-excitation species in the optical region (e.g. H I, He I, and Fe II). Zickgraf et al. (1986) explained such behaviour using a model in which the UV lines are formed in the fast and hot stellar wind in the polar regions of the CS envelope, while the optical lines are formed in the slower, denser, and cooler wind, forming the excretion disk. The SEDs of the B[e] supergiants also seem to be similar to that of MWC 349A. Their IR fluxes decrease towards longer wavelengths and no dusty features are seen in the $10\,\mu m$ region. Bjorkman (1998) modelled the SED of R 126, a typical B[e] supergiant from the LMC, and showed that the CS dust (which was considered to be composed from mostly amorphous carbon) can be formed in its disk. From these similarities and the parameters we adopted for MWC 349A, it seems more likely that the object is a B[e] supergiant, rather than a pre-main-sequence or a post-AGB star.

4. Discussion

Our observations, presented in Sect. 2, suggest that the IR source surrounding the central star of MWC 349A consists of two components. For example, in the H-band the diameter (along the major axis) of the Large Component is $115.7 \pm 7.6\,\mathrm{mas}$, corresponding to $190 \pm 13\,\mathrm{AU}$ (for a distance of $D=1.7$ kpc), while the diameter of the Small Component is only $26.9 \pm 3.0\,\mathrm{mas}$, corresponding to $41 \pm 4\,\mathrm{AU}$.

One of the possible interpretations of this finding is that the emission of the inner parts of the disk is dominated by the bound-free and free-free radiation of the CS gas, while the outer parts of the disk are observed mainly due to emission of the CS dust. This interpreta-

tion is supported by the strong emission-line spectrum of MWC 349A, which implies a significant contribution of the CS gas continuum emission in the red and near-IR spectral region (up to $\lambda \sim 1$–$2\,\mu$m). Moreover, the CS gas would occupy a less extended spatial region – closer to the star – than the dust. Therefore, the CS gas can be observed as an enhancement in the visibilities at high spatial frequencies. Within this interpretation the size of the more compact component indicates the radial distance at which the dust sublimation in the disk occurs.

We can also consider another interpretation of the observed two-component structure. The structure of the IR source in MWC 349A could be caused by a discontinuity of the mass transfer rate in the CS disk. If this discontinuity does occur, a significant fraction of the kinetic energy of the material flowing in the disk will be converted into thermal energy and radiation. Hence, within this hypothesis an additional source of radiation, localized at the outer edge of the compact component, is expected. Such a source can be associated with the $H30\alpha$ recombination line maser, which according to Planesas, Martín-Pintado, & Serabin (1992) is generated in the CS disk at a radial distance of about 40 AU from the central star of MWC 349A. Though this association remains to be justified, it suggests that a more detailed modeling of the mass transfer discontinuity might be very fruitful.

Among the possible reasons for the discontinuity, one can indicate an instability of the CS disk and the interaction between the material presently ejecting from the central star with a fossil disk-like shell, which was formed during a previous epoch of evolution of MWC 349A. The existence of a fossil shell is not very unusual, if MWC 349A is an evolved star (see Sect. 3). Furthermore, it cannot be excluded that MWC 349A is a close binary system. Indeed, C85 admitted that their L and M_V estimates do not fit those of any normal star. They suggested that the problem lies either in the unusually slow and dense wind or in the presence of a cool companion (also proposed earlier by Blanco & Tarafdar 1978), whose spectral signature however has not been detected. Another type of the secondary (a massive protoplanet) was suggested by Jorgenson et al. (2000), who found regular variations in the object's optical brightness with a period of 9 years, but stated that the brightness variation mechanism is unclear. This idea is also incompatible with our conclusion about the evolutionary state of MWC 349A. At the same time, the binary hypothesis is worth additional consideration, although we cannot rule out that MWC 349A is a single B[e] supergiant. The presence of a secondary companion makes it easier to explain such properties of MWC 349A as the extremely strong Balmer emission and a non-spherical distribution of the CS matter. We note here that MWC 349B is not considered physically connected with MWC 349A.

A few B[e] supergiants have been found in the Milky Way. The observed features of one of them (CI Cam, e.g. the emission line profiles and the SED shape) are for the most part very similar to those of MWC 349A. There have been no attempts to resolve the envelope of CI Cam, which

seems to be located further away from the Sun (at 3–5 kpc, see Robinson, Ivans, & Welsh 2002 and Miroshnichenko et al. 2002 for different points of view), with speckle interferometry. This object experienced a strong outburst, detected in all spectral regions from the γ-ray to the radio, which was explained by the interaction in a binary system, containing a B[e] supergiant and a compact degenerate companion (a neutron star or a black hole, see Robinson et al. 2002). It is difficult to detect secondary companions in systems where it is invisible in the quiescent state. The same problem concerns the B[e] supergiants of the Magellanic Clouds, as they are faint and very distant. However, Zickgraf et al. (1996) reported that one of these objects, R4, has been proven to be a binary through the detection of regular radial velocity variations. Thus, binarity may be a key property to explain the observational features of B[e] supergiants. However, such systematic observations as spectroscopy and optical photometry (not available yet for MWC 349A) are needed in order to find traces of the secondary and put constraints on its properties.

The 9-year period found by Jorgenson et al. (2000) may be due to orbital motion. Assuming a system mass of $26\,M_\odot$, these authors mentioned that such an orbital period would correspond to a separation of 12–15 AU, which in turn corresponds to an angular separation of ~ 7–$10\,$mas at a distance of 1.7 kpc. To verify this, an order of magnitude of better spatial resolution than that of the existing observations is needed. Such a resolution can soon be achieved with modern interferometers.

5. Conclusions

We have obtained and analyzed diffraction-limited (resolutions 43–74 mas) speckle interferometric $J-$, $H-$, and K-band observations of MWC 349A. The images are elongated at all wavelengths with an axial ratio of ~ 0.7. Their position angles coincide with those obtained by Danchi et al. 2001. The best-fit model to the observed visibilities consists of 2 elliptical components (e.g. J-band size: $\sim 22 \times 12\,$mas and $\sim 119 \times 74\,$mas; Table 3). The inner component probably corresponds to the CS gas emission, while the outer one can be produced by a dusty disk, whose symmetry plane is seen at a low inclination angle.

We also summarized existing information about observed parameters of MWC 349A, and hypotheses previously suggested to explain its nature. This analysis resulted in a new luminosity estimate, which is based on the assumption that the object belongs to Cyg OB2 (see Meyer et al. 2002 for the justification) and indicates that it is more luminous than was suggested before. We concluded that MWC 349A is unlikely to be a pre-main-sequence star or a young planetary nebula. Its fundamental parameters and observed features (the strong emission-line spectrum and dust emission) are more consistent with those of B[e] supergiants.

A binary nature of MWC 349A cannot be excluded, but this hypothesis needs further observational testing. In

particular, optical photometric observations to search for possible brightness variations, and high-resolution spectroscopy to search for radial velocity variations both associated with the orbital motion are very important for further progress in the understanding of this puzzling object. Quantitative analysis of our speckle images within this model will be presented elsewhere.

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