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The unusual pre-main-sequence star V718 Persei (HMW 15)

Photometry and spectroscopy across the eclipse⋆

V. Grinin[1], H. C. Stempels[2], G. F. Gahm[3], S. Sergeev[4], A. Arkharov[1], O. Barsunova[1,5], and L. Tambovtseva[1]

[1] Pulkovo Astronomical Observatory, 196140, Pulkovskoe shosse 65, St. Petersburg, Russia
e-mail: grinin@gao.spb.ru
[2] School of Physics & Astronomy, University of St. Andrews, North Haugh, St Andrews KY16 8RQ, Scotland
e-mail: Eric.Stempels@st-andrews.ac.uk
[3] Stockholm Observatory, AlbaNova University Centre, 106 91 Stockholm, Sweden
e-mail: gahm@astro.su.se
[4] Crimean Astrophysical Observatory, Crimea, Nauchny, Ukraine
e-mail: sergeev@crao.crimea.ua
[5] Sobolev Astronomical Institute, St. Petersburg State University, St. Petersburg, Russia

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ABSTRACT

Context. The remarkable pre-main-sequence object V718 Per (HMW 15, H187) in the young cluster IC 348 periodically undergoes long-lasting eclipses caused by variable amounts of circumstellar dust in the line-of-sight to the star. It has been speculated that the star is a close binary and similar to another unusual eclipsing object, KH 15D.

Aims. We have submitted V718 Per to a detailed photometric and spectroscopic study to investigate how regular the recurrent eclipses are, to find out more about the properties of the stellar object and the occulting circumstellar material, and to look for signatures of a possible binary component.

Methods. V718 Per was monitored photometrically from the optical to the near-infrared (NIR). We also obtained high-resolution optical spectra with the Keck telescope at minimum as well as at maximum brightness. We derived the fundamental photospheric parameters of this star by comparing with synthetic spectra.

Results. Our photometric data show that the eclipses are very symmetric and persistent, and that the extinction law of the foreground occulting dust deviates only little from what is expected for "normal" interstellar material. The stellar parameters of V718 Per indicate a primordial abundance of Li and a surface temperature of $T_{\rm eff} \approx 5200$ K. Remarkably, the in-eclipse spectrum shows a significant broadening of the photospheric absorption lines, as well as a slightly lower stellar surface temperature. In addition, weak emission components appear in the absorption lines of Hα and the Ca II IR triplet lines. We did not detect any signs of atomic or molecular features related to the occulting body in the in-eclipse spectrum. We also found no evidence of any radial velocity changes in V718 Per to within about ± 80 m s^{-1}, which for an edge-on system corresponds to a maximum companion mass of $\sim 6\ M_{\rm Jup}$.

Conclusions. Our observations suggest that V718 Per is a single star, and thus very different from the related binary system KH 15D. We conclude that V718 Per is surrounded by an edge-on circumstellar disk with an irregular mass distribution orbiting at a distance of 3.3 AU from the star, presumably at the inner disk edge. To produce the prolonged eclipses, the occulting feature must extend along more than half of the inner disk edge. The change in stellar surface temperature and the emission line activity observed could be related to spot activity. We ascribe the broadening of photospheric absorption lines during the eclipse to forward scattering of stellar light in the circumstellar dust feature.

Key words. stars: pre-main sequence – stars: peculiar – stars: individual: V718 Per – stars: circumstellar matter

1. Introduction

V718 Per, also known as HMW 15 and H 187[1], is a late-type pre-main-sequence star in the nearby, young open cluster IC 348. Comprehensive photometric monitoring of V718 Per by Cohen et al. (2003) revealed a very unusual eclipse in this object. They detected an extremely long and smooth eclipse ($t_{\rm ecl} \approx 3.5$ yrs and an eclipse depth of $\sim 0.7^{\rm m}$), and earlier scattered photometric data suggested that these eclipses may be recurrent (see Cohen et al. 2004). Late 2004, V718 Per entered a second eclipse, in shape and depth very similar to the first one (Barsunova et al. 2005). More detailed observations by Nordhagen et al. (2006) show that V718 Per undergoes recurrent, 3.5 year long eclipses with a period of $P = 4.7 \pm 0.1$ years (see also Grinin et al. 2006a). Thus, given the very long eclipse duration and its comparitively short period, this system is one of the most exotic eclipsing systems known. The closest analog to V718 Per is probably the system KH 15D, a weak-line T Tauri binary system that experiences eclipses by its circumbinary disk (Kearns & Herbst 1998; Hamilton et al. 2001; Winn et al. 2006).

The extremely long duration of the eclipse, combined with the comparatively short period rules out periodic eclipses by a compact body, like a stellar or planetary companion, as the possible cause of variability. Since a 4.7 year period suggests orbital motion as the underlying cause, most working hypotheses propose that the eclipses are produced by an extended body,

⋆ Based on observations collected at the Crimean Astrophysical Observatory, Ukraine; the W. M. Keck Observatory, Hawaii, USA and the Campo Imperatore Observatory, Italy.

[1] Other designations: TJ 108, LDL 35, LRL 35.

like an irregular or warped circumstellar or circumbinary disk seen nearly edge-on (Cohen et al. 2004; Nordhagen et al. 2006; Grinin et al. 2006a). A still unresolved question is whether or not V718 Per is a close binary, similar to KH 15D, where the orbital displacement of the stars would periodically hide one or both components behind a shared circumbinary disk. The fact that the spectral types assigned to the object cover a rather large range, G8 – K6 (Herbig 1998; Luhman et al. 1998), and may even change with wavelength, could flag the presence of two stellar spectra. As pointed out by Nordhagen et al. (2006), a variable radial velocity with an amplitude of several km s^{-1} should then be detectable from high-resolution spectroscopy.

In this paper we present the results of our photometric and spectroscopic observations of V718 Per. We have obtained multi-waveband photometry, as well as two high-resolution spectroscopic observations with the Keck telescope. These observations, together with existing infrared photometry, provide us with a basis for improving our understanding of the nature of this object and its unusual eclipses, and we can address the question of binarity of V718 Per.

2. Observations

2.1. Photometry

We observed the entire 2005–2007 eclipse of V718 Per with *v*, *r* and *I*-band photometry with the AZT-8 (0.7 m) telescope of the Crimean Astrophysical Observatory, Ukraine. After standard image reduction, the obtained aperture photometry was transformed to the Johnson-Cousins *V*, *R* and *I*-bands. Since V718 Per is located in a star forming region, almost all the stars in the field exibit small brightness fluctuations. We selected three reference stars in the field (H139, H205, and H210) that show only small brightness variations ($\sim 0.05^{m}$). They were calibrated via the photometric data of the stars TJ32, TJ36 and TJ68 derived by Trullols & Jordi (1997). We estimate the accuracy of the obtained photometric data to be about 0.03^{m} in *V* and *R*, and 0.02^{m} in *I*. The photomeric data extend the series presented earlier by Grinin et al. (2006a).

Photometric observations of V718 Per in the near-IR wavebands *J*, *H* and *K* were obtained with the SWIRCAM camera of the 1.1 m telescope of the Pulkovo Astronomical Observatory located at the Campo Imperatore Observatory, Italy. These CCD images were reduced with standard reduction techniques, including bad pixel removal, flat-field correction and sky subtraction. The differential calibration of the photometric system with respect to the Johnson system was performed with the help of the same reference stars as we used for the *I*-band. The final accuracy of the *J*, *H* and *K*-band data is about 0.02^{m}.

V718 Per was also observed in the 3.6, 4.5, 5.8 and 8.0 μm bands with IRAC on the Spitzer Space Telescope in February 2004, September 2004, and October 2005 (3.6 and 5.8 μm only). Data from February 2004 were presented by Lada et al. (2006) and Muench et al. (2007), who also determined a limiting magnitude of 5.31 in the 24 μm MIPS band. We retrieved all three datasets from the data archive of the Spitzer Science Center and determined the fluxes of V718 Per in the four IRAC wavebands using the aperture photometry tasks of the SExtractor package (Bertin & Arnouts 1996). We used an aperture radius of 10 pixels and zero-point fluxes recommended by the Spitzer Science Center (Reach et al. 2005). For the dataset from February 2004 we find for V718 Per 3.6 and 4.5 μm-band magnitudes that are consistent with those presented by Lada et al. (2006); the 5.8 and 8.0 μm-band magnitudes are slightly brighter, most likely because of differences in the technique used to subtract the complex background around V718 Per. We list our measurements in Table 1.

Table 1. IR magnitudes derived from *Spitzer* observations of V718 Per.

Date	3.6 μm	4.5 μm	5.8 μm	8.0 μm
2004–02–11	9.37 ± 0.02	9.26 ± 0.02	9.01 ± 0.02	8.32 ± 0.03
2004–09–08	9.46 ± 0.02	9.39 ± 0.02	9.17 ± 0.02	8.56 ± 0.02
2005–10–06	9.62 ± 0.02	–	9.37 ± 0.04	–

2.2. Spectroscopy

Two high-resolution ($R = 45\,000$) spectra of V718 Per, covering 4800–8700 Å, were obtained with the HIRES spectrograph of the 10 m Keck telescope on November 23, 2005 and December 10, 2006. The timing of the observations is such that the first spectrum was obtained close to the eclipse minimum (hereafter called the in-eclipse spectrum), while the second spectrum was obtained about a quarter of a phase later (hereafter called the out-of-eclipse spectrum). Although V718 Per was considerably brighter in 2006, the out-of-eclipse spectrum has a lower signal-to-noise due to the poor weather conditions at the time.

3. Results

An overview of the photometric observations of V718 Per from the *I*-band to 5.8 μm is presented in the upper panels of Fig. 1. *I*-band data collected so far, and the additional *V* and *R* data, show that the last eclipse was very similar to the preceding one, which is demonstrated for the *I*-band in the lower panel of Fig. 1, where the two eclipses are folded with the 4.7 year period. Only minor deviations occur from the average at a given phase suggesting that the eclipses are caused by the same structure in the line-of-sight. Furthermore, the shape of the eclipses is almost symmetric around the centre of the eclipse, except for a small deviation at the end of the last eclipse.

V718 Per becomes redder with decreasing brightness as demonstrated in the *V* versus $(V - I)$ diagram shown in Fig. 2, where also the reddening line expected from obscuration by interstellar type grains is drawn. The colour changes are similar during states of increasing and decreasing brightness.

3.1. Spectral properties and photospheric parameters

V718 Per has a typical late-type spectrum without any strong emission lines. The strong absorption line of Li I at 6708 Å confirms its young age. However, while the in- and out-of-eclipse spectra are rather similar, there are a number of important differences. The most conspicuous is that the in-eclipse spectrum shows weak core emission in the strong absorption lines of Hα and the Ca II IR triplet. In addition, the absorption lines appear broader in the in-eclipse spectrum. A large number of diffuse interstellar bands (DIBs) are visible in the spectrum of V718 Per, most notably the DIBs at 6613 and 6379 Å, but a number of weaker DIB features are present as well. These features indicate large foreground extinction to V718 Per. There is no evidence that the bands are strengthened in the in-eclipse spectrum, and we have no trace of any other atomic or molecular features that could be associated with the occulting object. Selected spectral regions of both spectra are plotted in Fig. 3.

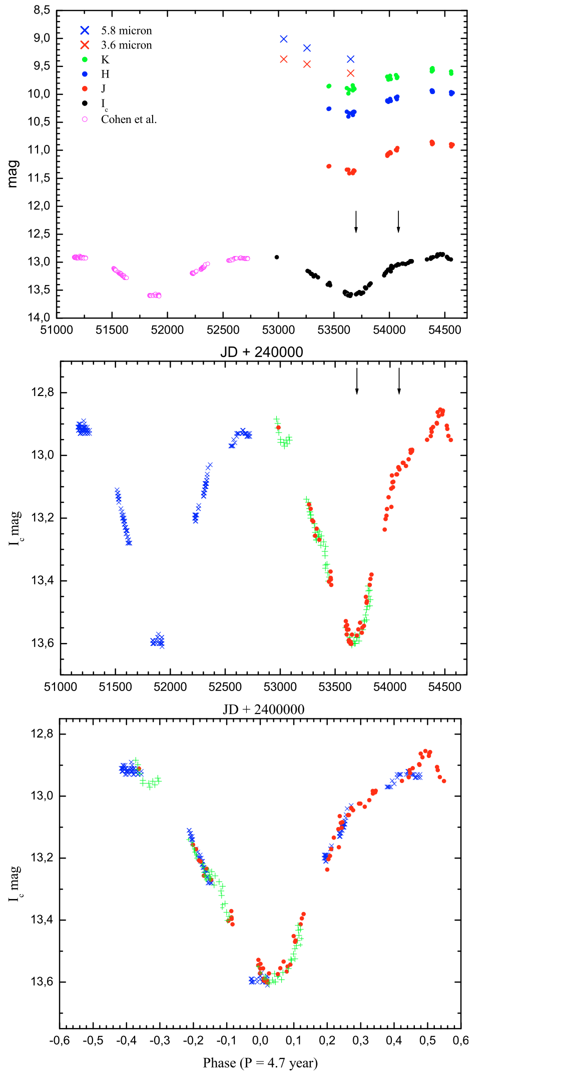

Fig. 1. *Top panel*: light curves of V718 Per from the I-band to 5.8 μm including data from *Spitzer*, Grinin et al. (2006a) and from Cohen (2004) corrected to the Johnson-Cousins system. The arrows indicate the times of spectroscopic observations. *Middle panel*: I-band observations from Cohen (2004) (blue, ×), Nordhagen et al. (2006) (green, +), and the present study (red, •). *Bottom panel*: the I-band data folded with a 4.7 year period. (This figure is available in color in electronic form.)

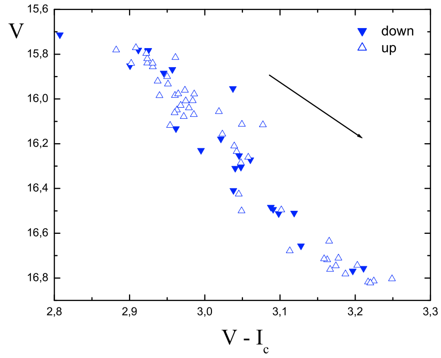

Fig. 2. The color–magnitude diagram V versus $(V - I)$. Filled triangles are points obtained when the star is fading in light and open triangles when it is brightening. The arrow indicates the standard reddening law.

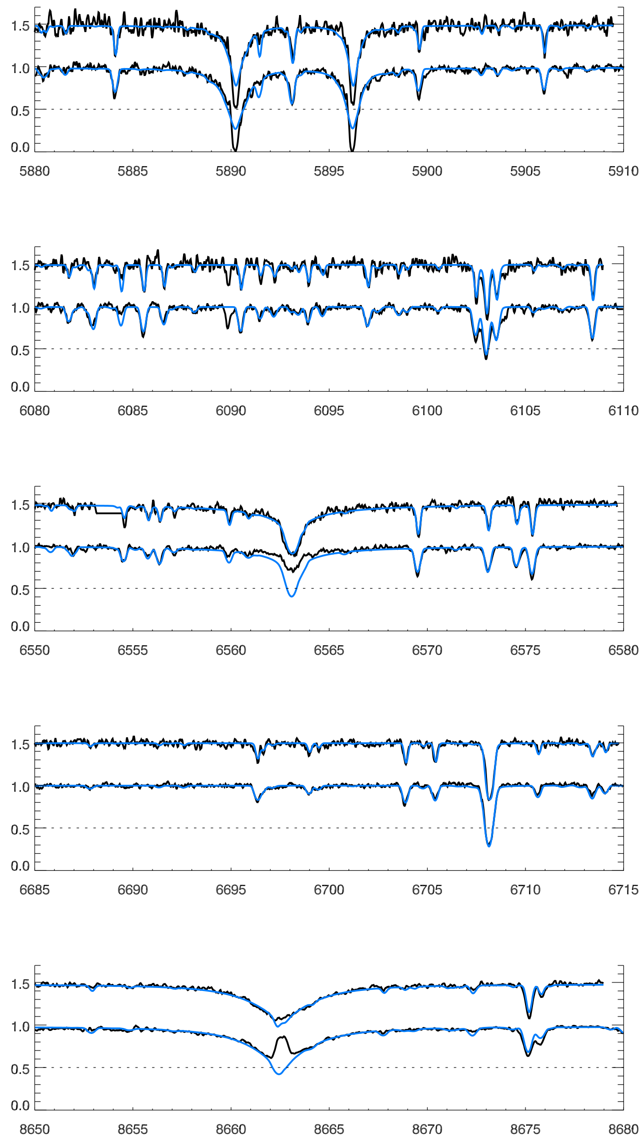

Fig. 3. Selected regions of the spectrum of V718 Per. In each panel we show continuum-normalized profiles from the in-eclipse spectrum, as well as the out-of-eclipse spectrum (offset with +0.5). Superimposed on each spectrum is a synthetic model spectrum (blue). The 30 Å wide regions cover from *top to bottom*: the strong Na D absorption lines; a number of metallic lines around 6100 Å; Hα; the strong line of Li I at 6707 Å; and one of the Ca II IR triplet lines at 8663 Å. (This figure is available in color in electronic form.)

Although V718 Per is a faint star for high-resolution spectroscopy ($V = 15.8^{\rm m}$ in its brightest state), the spectra obtained with the 10 m Keck are of sufficient quality to perform a spectroscopic analysis and determine the fundamental photospheric parameters. We used the IDL-based package *Spectroscopy Made Easy* (SME; Valenti & Piskunov 1996) for the calculation of synthetic spectra from model atmospheres and spectral line lists. SME also includes a least-squares algorithm that can solve for the stellar parameters that provide the best agreement with the observed spectrum, most importantly the effective temperature ($T_{\rm eff}$), surface gravity ($\log g$), metallicity ($[M/H]$), projected rotational velocity ($v \sin i$) and radial velocity ($v_{\rm rad}$).

In our analysis we used three spectral regions, together allowing us to determine these essential parameters. These regions include the following features: (1) Na I D 5890 Å, sensitive to both $T_{\rm eff}$ and $\log g$, (2) Hα 6563 Å and its broad wings, mainly sensitive to $T_{\rm eff}$ and (3) a large number of metal lines around 6100 Å, providing constraints on $[M/H]$, $v \sin i$

Table 2. Photospheric parameters derived for V718 Per.

Parameter	In-eclipse	Out-of-eclipse
$T_{\rm eff}$	5100 ± 100 K	5350 ± 100 K
$\log g$	3.7 ± 0.1	3.7 ± 0.1
$[M/H]$	0.1 ± 0.2	0.1 ± 0.2
$v \sin i$	10.1 ± 0.2 km s^{-1}	6.1 ± 0.2 km s^{-1}
$v_{\rm rad}$	14.504 ± 0.051 km s^{-1}	14.578 ± 0.060 km s^{-1}

and $v_{\rm rad}$. For our calculations we assumed a microturbulence $v_{\rm mic}$ = 1.0 km s^{-1} and a macroturbulence of $v_{\rm mac}$ = 4.0 km s^{-1}, both typical values for G–K type pre-main-sequence stars. Line data for these calculations were taken from the VALD atomic line database (Piskunov et al. 1995; Kupka et al. 1999), and model atmospheres from MARCS (Gustafsson et al. 2003).

We determined the fundamental photospheric parameters using all three wavelength ranges simultaneously, but independently for the in- and out-of-eclipse spectra. The results of these calculations are listed in Table 2. One of the resulting synthetic spectra is plotted in Fig. 3 for comparison with the observed spectra.

Our analysis suggests a small difference in effective temperatures, 5100 K versus 5350 K between in-eclipse and out-of-eclipse. This difference is close to the 3σ-limit, but the change is also supported by the change in the Na I D line profiles, as well as by changes in temperature-sensitive absorption line depth ratios. Our values of $T_{\rm eff}$ and $\log g$ derived for the out-of eclipse spectrum correspond to spectral class G9V or IV according to the calibrations by e.g. Kenyon & Hartmann (1995) and Cohen & Kuhi (1979). The range in temperature is relatively small, and corresponds to one subclass in terms of spectral type (G9–K0).

From the two spectra we measured an equivalent width of 385 ± 15 mÅ (in-eclipse) and 315 ± 15 mÅ (out-of-eclipse) for the Li I 6708 Å line, which for a star with a temperature of $T_{\rm eff}$ ≈ 5000 K and a gravity of $\log g$ ≈ 3.5 corresponds to a lithium abundance of $\log n$(Li) ≈ 3.2–3.5, indicative of a primordial abundance (Pavlenko & Magazzù 1996).

An important difference between the two spectra is that the in-eclipse spectrum shows stronger line broadening in the photospheric absorption lines than the out-of-eclipse spectrum. This is not an instrumental effect, since the spectra were obtained with an identical slit width. This is confirmed by the fact that the narrow telluric absorption components have identical line widths in both spectra.

3.2. Radial velocities

Accurate measurements of the radial velocity of V718 Per are important for determining the true nature of this object, especially since one working hypothesis is that V718 Per, in analogy with KH 15D, is a binary system. In order to measure the stellar radial velocity as accurately as possible, we first corrected instrumental drifts using telluric lines. The corrections recovered in this way were small. We then shifted the spectra to the heliocentric reference frame and determined from each spectrum the radial velocity of V718 Per by cross-correlating the position of 250 well-isolated absorption lines with their tabulated values.

The resulting heliocentric radial velocities are given in Table 2. The average velocity of 14.5 km s^{-1} is close to the average cluster velocity of 14.0 km s^{-1} (Kharchenko et al. 2005). The difference between the two measurements is small, only 74 ± 80 m s^{-1}. In other words, we found no detectable change in radial velocity between the two spectra. This is remarkable, since the first spectrum was obtained close to the deepest point of the eclipse, and the time elapsed between the two spectra corresponds to slightly less than a quarter of the 4.7 year period of eclipses. If V718 Per were an edge-on binary system such timing would be particularly sensitive to changes in radial velocity due to orbital motion. *Our non-detection of any change in radial velocity therefore suggests that V718 Per is a single system.*

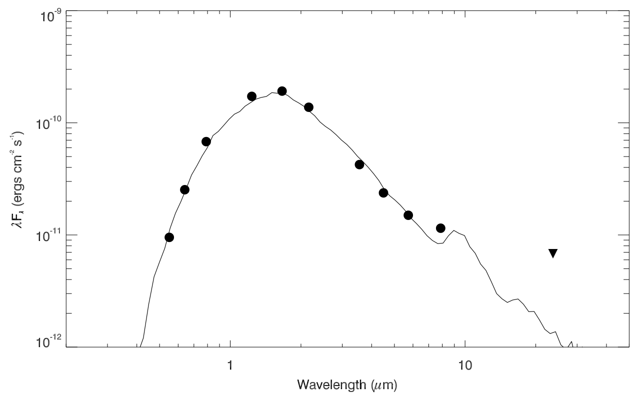

Fig. 4. Observed energy distribution of V718 Per as derived from photometry data outside the eclipse phase (points) fitted to a model spectral energy distribution (full-drawn curve), from which we derive basic parameters for the star. The triangle indicates the upper limit to the flux at 24 μm.

3.3. Stellar parameters

The distance to IC 348 is usually assumed to be ~320 pc, but has not been determined very precisely due to variable extinction conditions over the cluster (see the discussion by Herbig 1998). Even modern estimates based on *Hipparcos* parallaxes differ; 260 ± 25 pc given by Scholz et al. (1999) and 394 pc by Kharchenko et al. (2005). In the following we will adopt a distance of 300 pc to V718 Per.

In order to derive the extinction to V718 Per outside the eclipse phase and basic stellar parameters we have made use of the program developed by Robitaille et al. (2007), where we matched the observed out-of-eclipse energy distribution to a set of model spectral energy distributions extracted from model atmosphere calculations for young stars. The spectral energy distribution that shows the best agreement with the observed fluxes and (spectroscopic) temperature is shown in Fig. 4. This best-fitting model has an effective surface temperature of ~5300 K and an extinction of $A_{\rm V}$ = 4.7. The total integrated stellar luminosity (assuming a distance of 300 pc) is then 3.4 $L_\odot$. Placing the star in the HR-diagram and comparing its position to evolutionary model tracks by for instance Palla & Stahler (1999) and Siess et al. (2000) indicates that V718 Per is in its radiative contraction phase with a mass of ~1.6 $M_\odot$ and an age of ~5 Myr. The IC 348 cluster members were found to show an age spread of between 0.5 and 10 Myr by Luhman et al. (1998), but the pre-main sequence stars peak at 2.5 Myr with an age spread of 4 Myr according to Muench et al. (2007). From its location in the HR diagram, and also its spectral properties, we conclude that V718 Per is a post-T Tauri-star and among the older pre-main-sequence objects in the region. This is also supported by the lack of significant line emission, and the weak IR excess emission which indicates that V718 Per has only a thin, low-mass disk.

4. Discussion

Our observations shed some new light on the possible nature of V718 Per. Its location above the main sequence in the HR-diagram and the large Li abundance derived confirm the pre-main-sequence nature of the object. We have found that V718 Per is in its post-T Tauri phase, and in accordance the spectrum lacks emission lines, for instance of Hα. Since the last two eclipses have very similar light curves, the eclipses are likely to be caused by the same obscuring structure. Presumably this extended feature is part of a disk observed at high inclination, possibly edge-on. The disk produces the observed IR excess, but the absence of an IR excess in the *JHK* bands suggests that there is a gap with a radius of a few AU inside the disk edge. The extended circumstellar feature could represent an irregular azimuthal mass distribution in the disk, or a warped disk structure. The feature could also be related to spiral arm structures that developed because of perturbations from a secondary companion, as discussed by Sotnikova & Grinin (2007).

It has been speculated that V718 Per is a binary, but from our high-resolution spectra we find no detectable change in radial velocity. If V718 Per is indeed experiencing occultations from its circumstellar disk, it is probably correct to assume that the systems is observed edge-on and it is therefore most likely a single star and not similar to KH 15D. From the eclipse period of 4.7 years and a stellar mass of 1.6 $M_{\odot}$ (see Sect. 3.4), the occulting structure is orbiting at a distance of about 3.3 AU from the star, presumably at the inner disk radius. The presence of a central gap can be a natural consequence of V718 Per being in a relatively evolved pre-main-sequence phase of evolution, but a stable irregularity in the disk may flag the presence of a perturbing low-mass object, for instance in 1:1 resonance motion (see Ozernoy et al. 2000). From the limits on any radial velocity change of the star (Table 2), we find that the mass of any planet orbiting close to the disk plane and inside the disk edge cannot exceed 6 $M_{\rm Jup}$. A warped disk edge could in principle be maintained by a planet in an inclined orbit, in which case the perturbing object can be more massive.

When V718 Per declines in brightness, it becomes redder, and we found evidence that the star becomes somewhat cooler. At the same time the absorption lines become broader. We investigated the exact shape of the absporption line profiles using the technique of least-squares deconvolution (LSD, see Donati et al. 1997), which allows us to study even the smallest changes in the shape and depth of spectral lines. LSD reconstructs a "best-average" line profile by numerically combining the shape of a large number of absorption lines. For our spectra of V718 Per, we reconstructed these "best-average" absorption line profiles using the same narrow and isolated absorption lines as we used for the determination of radial velcocities. The reconstructed profiles clearly show that the in-eclipse profiles are substantially broader than the out-of-eclipse profiles, and that the out-of-eclipse profiles are only slightly shallower than the in-eclipse profiles (Fig. 5). Hence, the photospheric absorption lines increase in equivalent width with decreasing brightness in accordance with the change in $T_{\rm eff}$. Moreover, some lines show emission reversals at minimum light (see Fig. 3). The spectrum of V718 Per is therefore rather different in the two phases observed.

The Ca II and Hα emission components seen in the in-eclipse spectrum are too strong to be explained entirely as an effect of changing the continuum-to-line contrast between the in- and out-of-eclipse spectra. Such an effect would arise if for instance the emission region is extended and becomes less occulted than the stellar disk by a sharp dust screen in the foreground. The emission components are central and relatively narrow and are likely to originate close to the star. We conclude that the stellar photosphere and an associated emission region has changed between the time the two spectra were taken. With only two spectra we cannot speculate on how this change comes about. It could be related to a larger surface coverage of dark stellar spots, which happened to occur during the time the in-eclipse spectrum was exposed. This would explain the observed small shift towards cooler surface temperatures and also the enhanced "chromospheric" emission. There is no trace of any rotational modulation from spots in the light curves. A variable degree of spot activity must then be confined to the polar regions of the star.

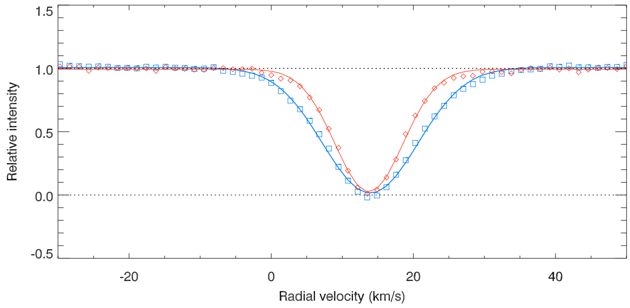

Fig. 5. The "best-average" absorption line profiles reconstructed with the technique of least-squares deconvolution (LSD – see text), plotted in the heliocentric reference frame. The (narrow) in-eclipse profile is shown as red diamonds, and the (wide) out-of-eclipse profile as blue squares. For each set of points a Gaussian curve that best fits the data is overplotted. No rescaling has been applied to the individual profiles. (This figure is available in color in electronic form.)

However, stellar surface spots cannot explain the observed increase in the broadening of the photospheric absorption lines. The changes in the absorption lines also cannot be explained by line-doubling from a binary system, since that would conserve the total equivalent width. Instead, we propose that this line broadening is a consequence of increasing light scattering when the thick part of the disk passes the line-of-sight to the star. The Keplerian velocity of a circumstellar feature with a 4.7 year period is ~21 km s^{-1}, which is sufficient to broaden the absorption line profiles by ~4 km s^{-1}. Since the circumstellar feature must extend over at least half a circle along the disk edge, scattering must be anisotropic, with a strong preference of forward scattering. Similar line profile changes resulting from scattering in T Tauri disks have been modelled by Grinin et al. (2006b) assuming similar asymmetric scattering functions.

More observations of V718 Per are warranted. Continued photometric and spectroscopic monitoring can establish more firmly the stability of the extended dust feature and also how the photospheric and chromospheric spectral features vary with time. V718 Per resembles the UX Ori stars, earlier type stars that undergo usually more irregular occultations by dusty blobs (see Grinin 2000). In analogy with these objects, we also expect the light from V718 Per to be polarized, and that the degree of linear polarization should increase drastically with decreasing brightness, which can be tested by observations. Finally, more information on the mid-IR and sub-mm fluxes is needed in order to probe and constrain the distribution and mass of the circumstellar material around V718 Per.

5. Conclusions

Our new photometric data of V718 Per (HMW 15, H187) extends previous measurements and confirms that this object shows long-lasting eclipses with a period of 4.7 years. The eclipses, which are very symmetric, are caused by occulting dust, and the colour changes suggest an extinction law of the foreground dust that deviates only little from what is expected for "normal" interstellar grains.

It has been speculated that V718 Per may be similar to the unusual close binary KH 15D, also showing periodic eclipses, which presumably are caused by different coverage of the orbiting stars by a circumbinary disk. We obtained two high-dispersion spectra of V718 Per, the first close to the deepest point of the eclipse and the other at a time outside eclipse with a time difference corresponding to roughly a quarter of the eclipse period. From these spectra we found no evidence of any change in the radial velocity of the star to within ± 80 m s^{-1}. Although we cannot be fully certain on the basis of two spectra, the absence of radial velocity variations in a system that experiences eclipses from its circumstellar material makes it very unlikely that V718 Per is a close binary. V718 Per seems therefore very different from KH 15D.

We confirm that the eclipses are caused by a stable extended, dusty structure orbiting at $\sim$3.3 AU from the star in an edge-on circumstellar disk. We have derived the SED of V718 Per outside eclipse, including IR fluxes obtained with *Spitzer*. This indicates that the star could be surrounded by a thin, low-mass disk. Because of the extended eclipse duration, the structure that causes the eclipses must extend over half a circle along the disk edge. A low-mass companion can in principle induce this structure, but the mass of any planet cannot exceed 6 $M_{\rm Jup}$ (assuming an edge-on system). The full amplitude of an eclipse amounts to 1.1 mag in the *V*-band, but there are no signs of any enhanced absorption features from circumstellar gas during eclipse. It appears that the occulting structure is rather void of gas.

V718 Per has a typical late-type absorption line spectrum without strong emission lines of e.g Hα. We have used theoretical synthetic spectra from model atmosphere and derived fundamental photospheric parameters. Our spectroscopic analysis shows that V718 Per has a primordial abundance of Li and a surface temperature of $T_{\rm eff} \approx 5200$ K. From the luminosity derived from its SED, and by comparing with theoretical evolution tracks, we find that V718 Per is in its post-T Tauri phase of evolution.

However, there are remarkable differences between the in-eclipse and out-of-eclipse spectrum. During the eclipse several spectral features show that the surface temperature is slightly lower than in the out-of-eclipse spectrum, corresponding to a change in spectral type from G9 to K0. In addition, narrow emission components appear in the absorption cores of the Hα and the Ca II IR triplet lines during eclipse, and the photospheric absorption lines become slightly broader. The change in stellar surface temperature and the emission line activity observed is puzzling. *Since V718 Per shows no short-term (rotational) photometric variability, this cannot be explained as the result of a variable coverage by starspots.* However, the observed spectral changes could be related to long-term changes in the activity near the polar regions. The broadening of the absorption lines we ascribe to forward scattering of stellar light in the circumstellar dust feature when it passes through the line-of-sight.

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