Long-term, multi-wavelength study of the eruptive YSO PV Cep

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Abstract

We studied the variations of of the young eruptive star PV Cep, based on our own, archival, and literature optical and infrared photometric and spectroscopic observations, extending from 1996 to 2026. Our aim is to understand the physical processes driving the variations of brightness, color, and spectrum of the star. We find that restructuring of the circumstellar dust, including changes in the shape and density of outflow cavity in response to variable accretion and wind, as well as episodic infall from the envelope play a substantial role in the observed changes.

PV Cephei

- Eruptive young star at 330 pc from Sun [Szilágyi et al., 2021].
- 2-years long outbursts in 1977–1979, 2004–2005, and 2015–2016 [Cohen et al., 1981, Kun et al., 2011, Lorenzetti et al., 2015].
- G8–K0 spectral type [Magakian and Movsesian, 2001], $M_* \sim 2$–$4\ M_\odot$ [Caratti o Garatti et al., 2013].
- $M_{disk} \approx 0.8\ M_\odot$ [Hamidouche, 2010].
- Flat type SED, $T_{bol} = 450$ K, $L_{bol} = 62\ L_\odot$ [Dunham et al., 2013].
- Parsec-scale HH flows HH 215, HH 315, HH 415 [Reipurth et al., 1997].

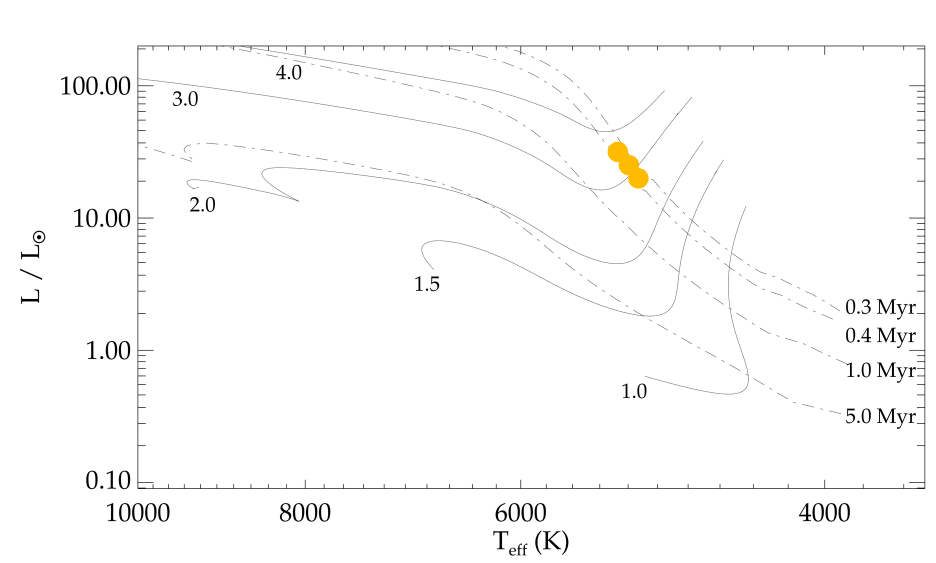

Figure 1: Estimated position of PV Cep in th HRD, supposing an age $\lesssim 0.4$ Myr [mean lifetime of protostellar envelopes, Evans et al., 2009] and spectral type G8–K0.

Data

- VR_CI_C, r, i photometric observations at Konkoly Observatory in 2004–2026; supplemented by *Gaia*, *ASAS-SN*, *ZTF*, and literature [Lorenzetti et al., 2011] data.
- Flux-calibrated near-infrared spectra, IRTF SpeX 2000, 2007, 2010, 2016, 2020
- Near IR: Sporadic JHK_s photometry; *Spitzer* 2004, 2006; *WISE* 2010; *NEOWISE* 2014–2024.
- Mid- and far-IR: *ISO* 1996; *Spitzer* 2004; *Akari* 2007; *Herschel* 2010; *SOFIA* 2019.
- Submillimeter [Sandell et al., 2011].

Light curves

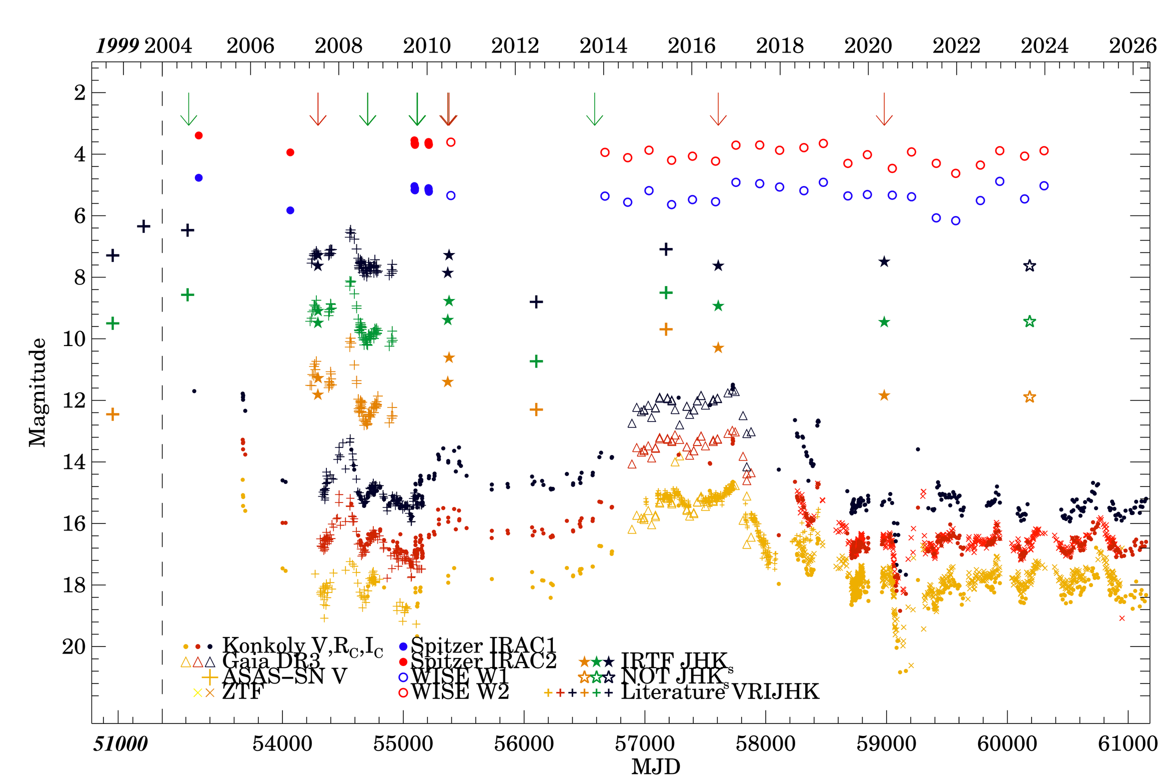

Figure 2:

Flux-calibrated IRTF spectra

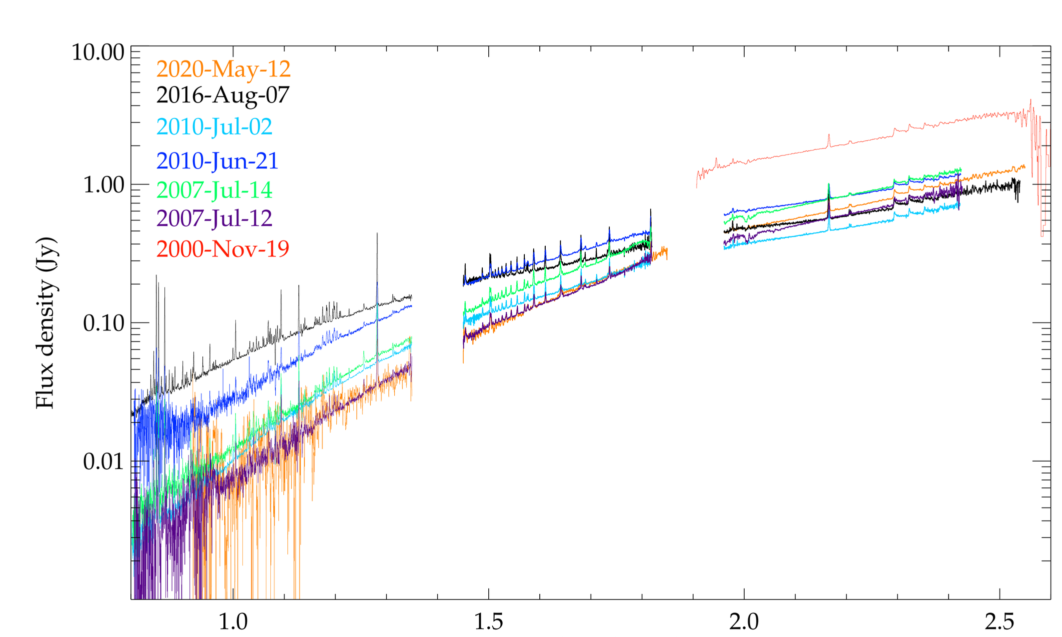

Figure 3:

Extinction from emission line flux ratios

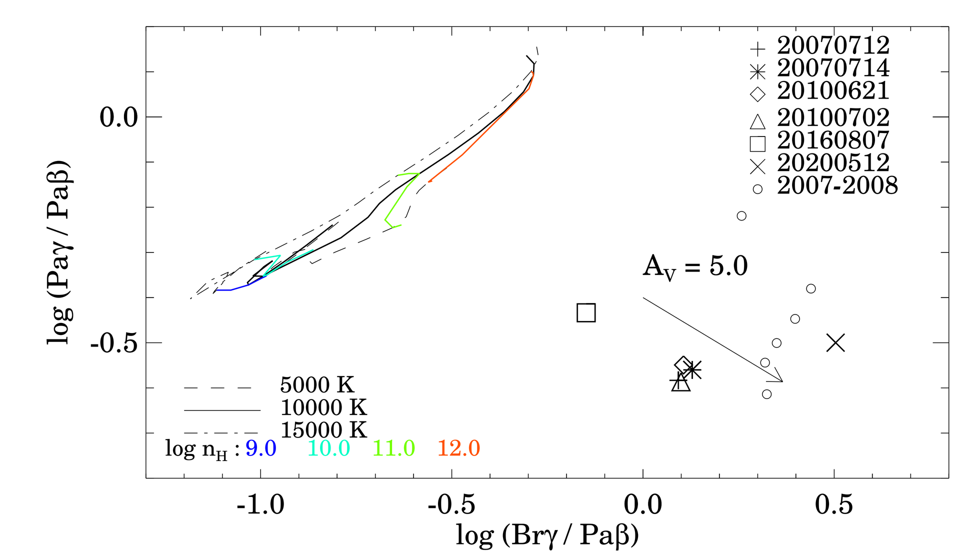

Figure 4: Ratio-ratio plot of Paγ / Paβ versus Brγ / Paβ fluxes [see Edwards et al., 2013], suggesting A_V variations between 8 and 15 mag. Theoretical ratios of models by Kwan and Fischer [2011] are also plotted.

Multi-epoch SED

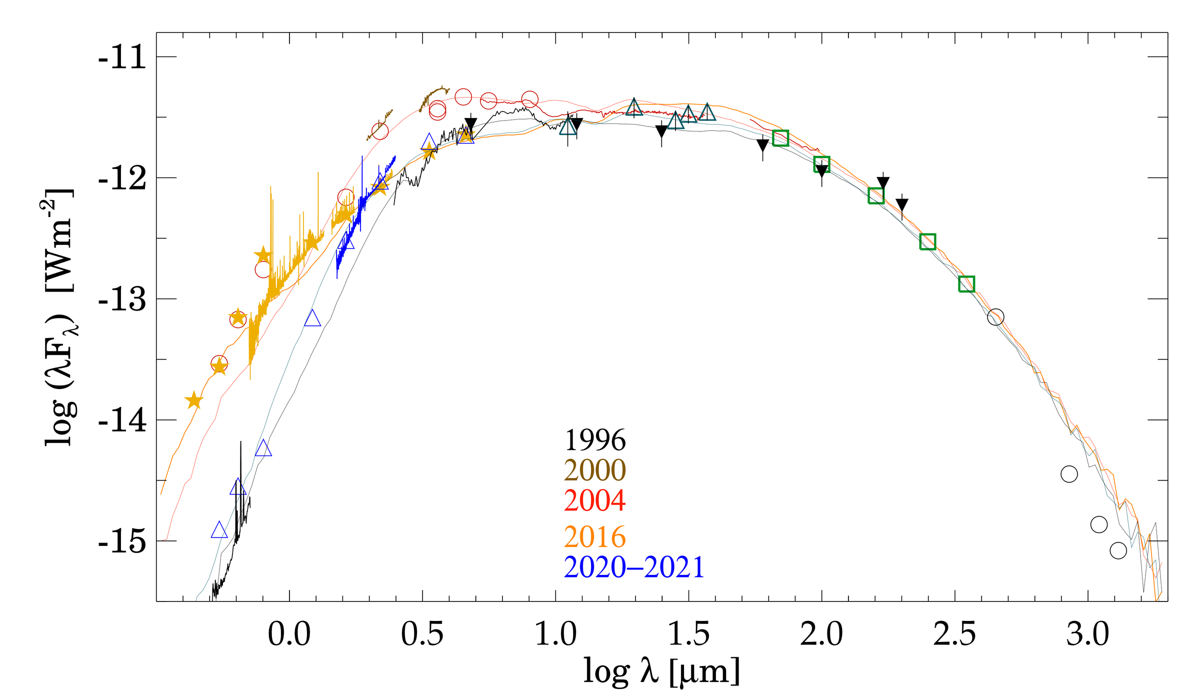

Figure 5: Variable spectral energy distribution of PV Cep between 1996 and 2020. Solid lines indicate the models fitted using the radiative transfer code of Whitney et al. [2003].

Adopted input parameters: $M_* = 3.2\ M_\odot$, $R_* = 6.0\ R_\odot$, $T_{eff} = 5030$ K, $M_{disk} = 0.8\ M_\odot$, $r_{disk} = R_{subl}$, $R_{disk} = 500$ au, $R_{env} = 5000$ au. disk radial density exponent 2.19.

Variable quantities to get satisfactory fits : disk accretion rate, area of hot spots, height of outflow cavity wall, density of the cavity at the envelope inner radius, envelope density at 1000 au.

Conclusion

PV Cep underwent a strongly variable period between 2004 and 2019, with several burst of various lengths and amplitudes, and then entered a low-brightness phase, with some hint of quasi-periodic changes, suggesting a disk asymmetry. Near-infrared spectra suggest a strongly accreting star both in bright and faint states, and line ratios indicate significant variations in the extinction. Modeling the SED variations suggests that, in addition to variations in accretion rate ($\sim 1 \times 10^{-6}$ to $5 \times 10^{-6}\ M_\odot\,yr^{-1}$), restructuring of the circumstellar dust, including changes in the inner disk and in the shape and density of outflow cavity, and infall of clumps from the envelope. contribute to the observed phenomena.

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