The Mass Accretion Rate of the Young Variable Star GM Cep

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GM Cep is a young Pre-Main Sequence source that presents rapid photometric variability of more than 2 mag in the optical bands. First studies have interpreted such variations as possible EXor-type outbursts (Sicilia-Aguilar et al. 2008), but subsequently important arguments in favor of a quasi-periodical UXor-type variability have been provided (Xiao et al. 2010; Chen et al. 2012; Semkov et al. 2015).

A powerful way to determine whether or not GM Cep is an eruptive variable is to evaluate the variation of the mass accretion rate ($\dot{M}_{acc}$) between low- and high-brightness phases. Between 2017 November and 2018 April GM Cep underwent a brightness increase from $V \sim 14.8$ to ~ 13.3 mag, then followed by a new fading at the end of April. With the aim to directly measure the mass accretion rate, we have observed GM Cep with the 1.22 m telescope + B&C spectrograph operated in Asiago by the University of Padova, obtaining seven spectra in the wavelength range between 3300 and 8050 Å ($\mathfrak{R} \sim 2400$). In all the spectra the dominant feature is the Hα line, always seen in emission. In addition, we have collected

optical BVR_CI_C photometry, from which we have determined the extinction toward the source by means of color–color diagrams. We get $A_V = 2.5 \pm 0.5$ mag.

The computation of $\dot{M}_{acc}$ is based on empirical relationships between the accretion luminosity (L_{acc}) and the luminosity of selected emission lines. The relation between the Hα luminosity ($L_{H\alpha}$) and L_{acc} has been derived by Alcalá et al. (2017):

$$\log(L_{acc}/L_{\odot}) = (1.13 \pm 0.05)\, L_{H\alpha} + (1.74 \pm 0.19), \quad (1)$$

L_{acc} can then been converted in $\dot{M}_{acc}$ through the relation by Gullbring et al. (1998):

$$\dot{M}_{acc}/M_{\odot}\ \mathrm{yr}^{-1} = \frac{L_{acc} R_*}{G M_*}\left(1 - \frac{R_*}{R_{in}}\right)^{-1}. \quad (2)$$

Equations (1) and (2) have been applied considering a distance of 825 pc (*Gaia* DR2, Brown et al. 2018), a stellar mass $M_* = 2.1\ M_{\odot}$, a radius $R_* = 3\ R_{\odot}$ (Sicilia-Aguilar et al. 2008), and an inner disk radius $R_{in} = 5R_*$. The Hα intrinsic flux at the different dates was computed by dereddening the observed flux for $A_V = 2.5$ mag.

In Figure 1 we plot our results (black data points). No significant enhancement of the mass accretion rate can be evidenced, being all the determinations very similar inside the errorbars. These latter take into account both the uncertainty in the flux measurement and that in the L_{acc} versus $L_{H\alpha}$ relationship. The average $\dot{M}_{acc}$ value is $(3.5 \pm 0.6) \times 10^{-8}\ M_{\odot}\ \mathrm{yr}^{-1}$, which is lower both than the determination of Semkov et al. (2015) of $18 \times 10^{-8}\ M_{\odot}\ \mathrm{yr}^{-1}$ and than the range estimated by Sicilia-Aguilar et al. (2008) between 5 and $30 \times 10^{-8}\ M_{\odot}\ \mathrm{yr}^{-1}$. Besides the fact that these values have been determined with a different method (Natta et al. 2004), it is remarkable that at the time of both these observations GM Cep was close to its maximum level of brightness, being $V \sim 12.9$ mag on 2008 June (Semkov et al. 2015) and $R \sim 12.9$ mag on 2001 June (Sicilia-Aguilar et al. 2008).

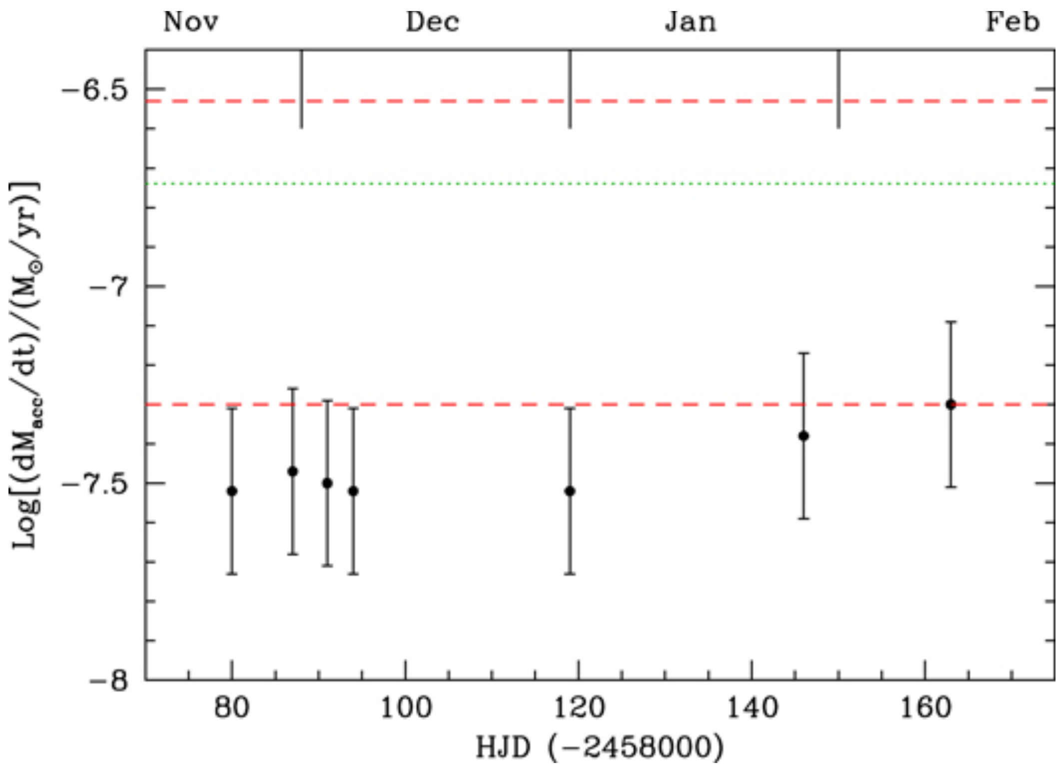

Figure 1. Mass accretion rates derived from the Hα line flux in different dates. $\dot{M}_{acc}$ values derived from the relation by Alcalá et al. (2017). Dotted green line is the value by Semkov et al. (2015), while the two red dashed lines delimit the range found by Sicilia-Aguilar et al. (2008).

In conclusion, we can affirm that the mass accretion rate has remained substantially unchanged during our monitoring period, although the source brightness has changed from 14.8 to 13.3 mag. Significant variations of $\dot{M}_{acc}$ could occur if the GM Cep luminosity increased further.

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