Mass and orbit constraints of the gamma-ray binary LS 5039

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LS 5039: an enigmatic binary

- A high-mass X-ray binary with radio lobes and a very-high energy (VHE) gamma-ray production → it is one of the peculiar gamma-ray binaries
- No signs of an accretion disk
- Source of VHE radiation: inside or outside the binary orbit?
- **Primary component**: O6.5V((f)) star
  - **Secondary component**:
    - Black hole (?)
    - Non-accreting young pulsar (?)
Radial velocities and parameters

- The highest resolution, homogeneous spectral dataset for LS 5039 obtained with ANU 2.3m telescope and MPG/ESO-2.2m telescope (FEROS) (~40 hours; 3800-6750 Å; R=23,000)

- A systematic blueshift of H I and He I lines with respect to He II lines (contamination from the stellar wind)

- Orbital parameters from modeling with WD 2003 code → similar results to previous ones, but definitely lower value of eccentricity (~0.25)

- No signs of the pulsation of the O star assumed by Casares et al. (2010)
Mass constraints from *MOST*-photometry

- Ultraprecise photometry with *MOST* satellite; possible variability at the level of 2 mmag
- LC simulations with WD-code (with the mass function fixed):
  - Decreasing inclination → no decreasing amplitude (Casares et al. 2005)
  - Amplitude decreases with increasing total mass or decreasing eccentricity

**Conclusion:**
Photometric analysis support the lower eccentricity and strengthens black hole scenario ($M_x > 1.8 \ M_{\text{Sun}}$), but does not fully exclude the neutron star scenario.
Stellar wind from the O component

- Changes of equivalent widths (EW) of H-alpha between 2.50 and 2.85 Å → mass loss rate of the O star: $3.7 - 4.8 \times 10^{-7} \, M_{\odot} \, \text{yr}^{-1}$

- Significant changes of EWs of two other lines (H-beta, He I $\lambda$5875) during the orbit

- The weakest absorption: $\phi \sim 0.65-0.75$ (inferior conjunction) → focusing of the stellar wind toward the compact object (?)