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

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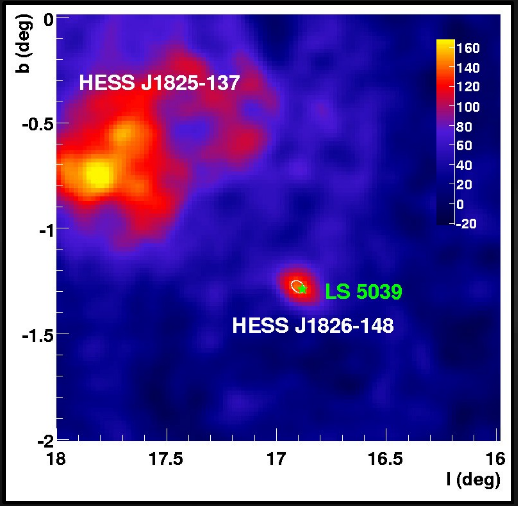
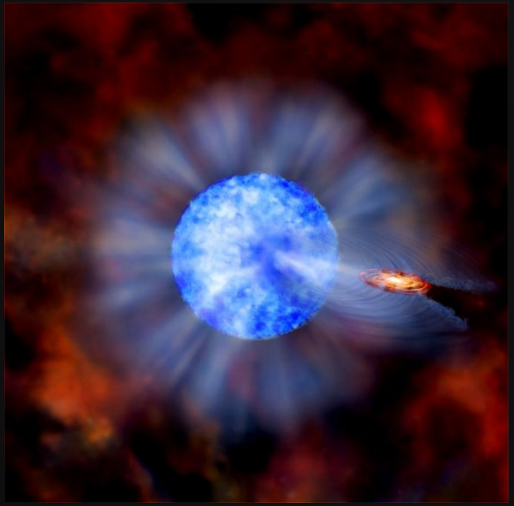
LS 5039: an enigmatic binary

- 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

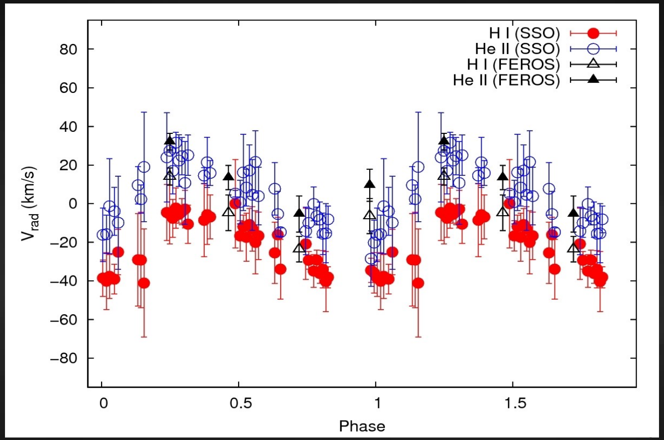
  Secondary component:
  - Black hole (?)
  - Non-accreting young pulsar (?)





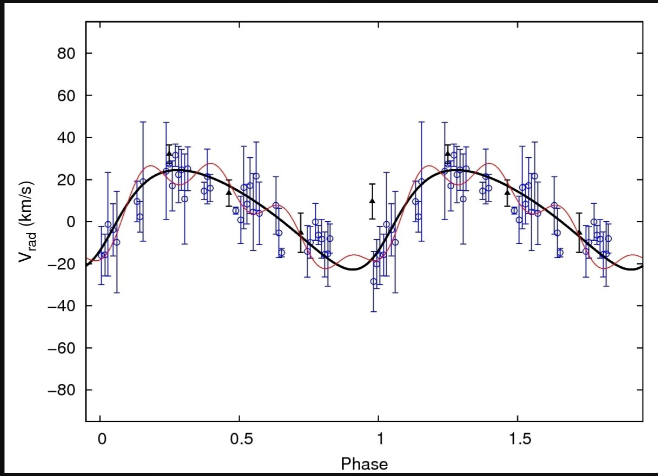
Radial velocities and parameters

- 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)

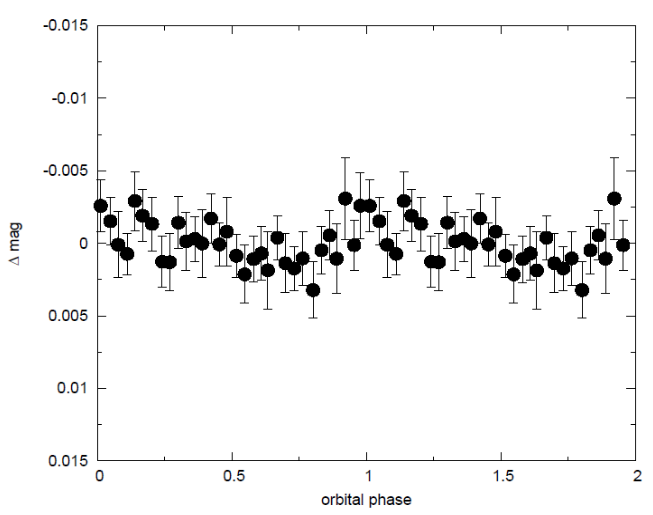
- Orbital parameters from modeling with WD 2003 code
  → similar results to previous ones, but definitely lower value of eccentricity (~0.25)

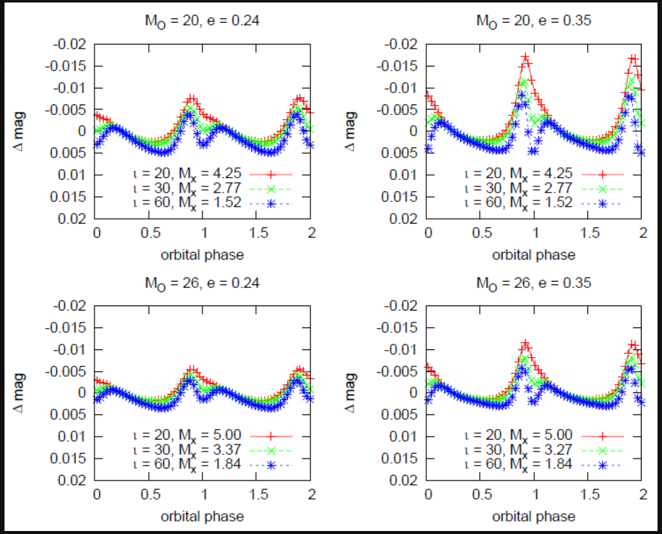


- No signs of the pulsation of the O star assumed by Casares et al. (2010)

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

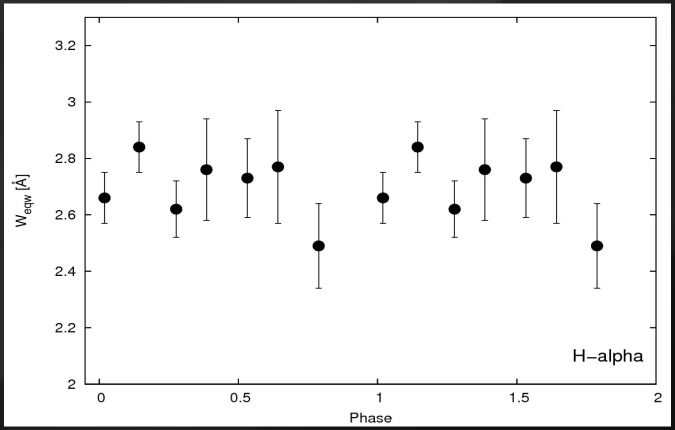




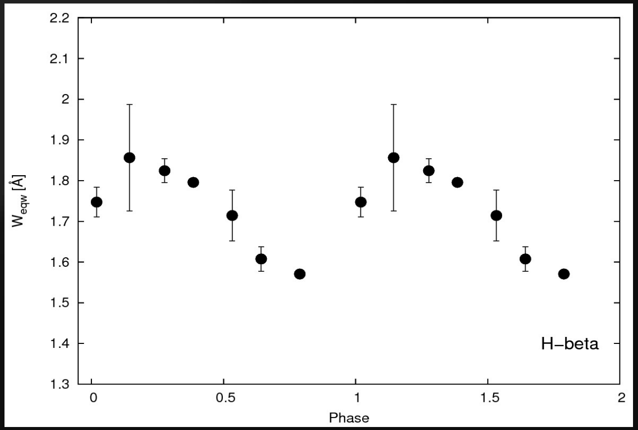
<u>Conclusion</u>:
Photometric analysis support the lower eccentricity and strengthens black hole scenario ($M_x > 1.8\ M_{Sun}$), but does not fully exlude the neutron star scenario.

Stellar wind from the O component

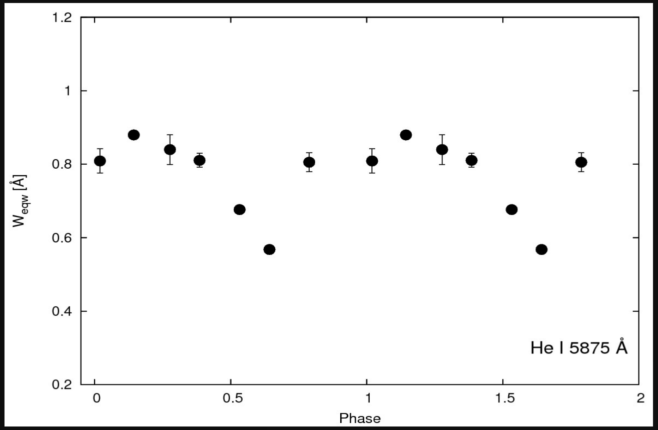
- Changes of equivalent widths (EW) of H-alpha between 2.50 and 2.85 Å → mass loss rate of the O star: 3.7 – 4.8 x 10^{-7} M_{Sun} yr^{-1}
- Significant changes of EWs of two other lines (H-beta, He I λ5875) during the orbit
- The weakest absorption: φ ~ 0.65-0.75 (inferior conjuction) → focusing of the stellar wind toward the compact object (?)



H-alpha



H-beta



He I λ5875

Sarty et al. 2011, MNRAS, 411, 1293