

# Detection of White Dwarf Companions to Blue Lurkers in M67



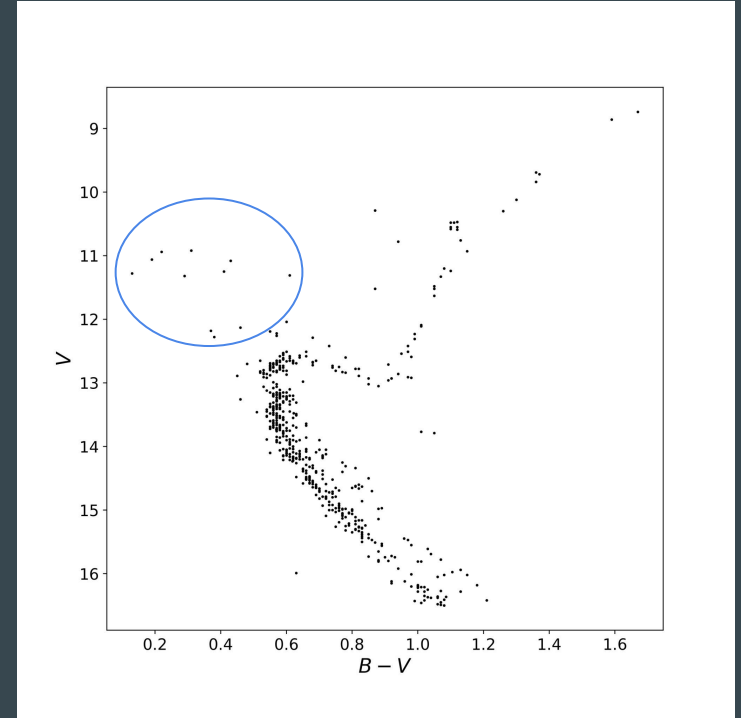
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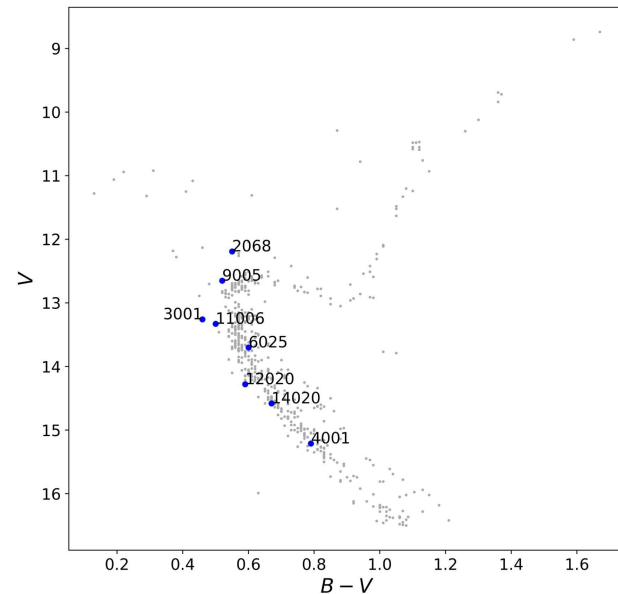
# Classical Blue Stragglers

- Bluer and brighter than the main-sequence turnoff of a cluster
- Challenge the model of single-stellar evolution
- Thought to form through three pathways:
  - Stellar collisions
  - Merger of inner binaries
  - Mass transfer from a companion star



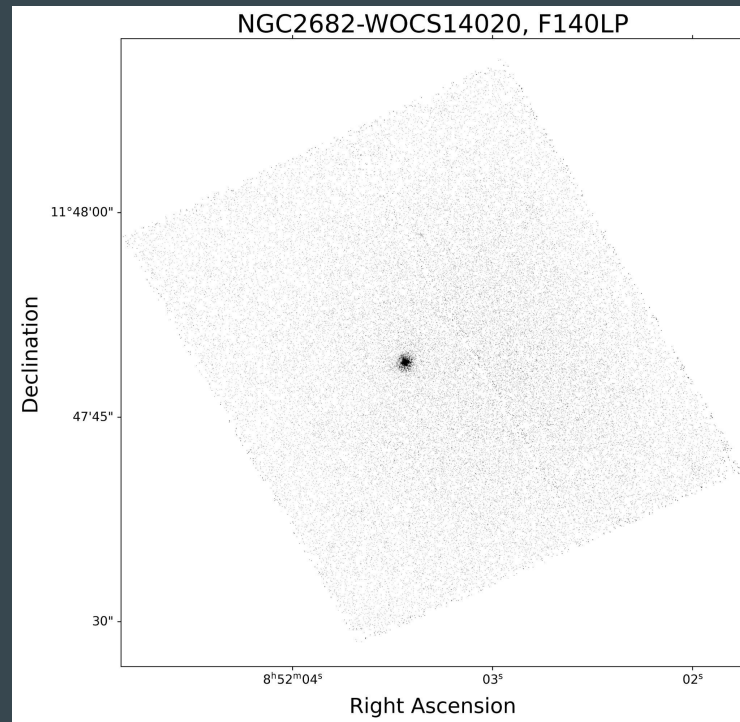
# The Blue Lurkers

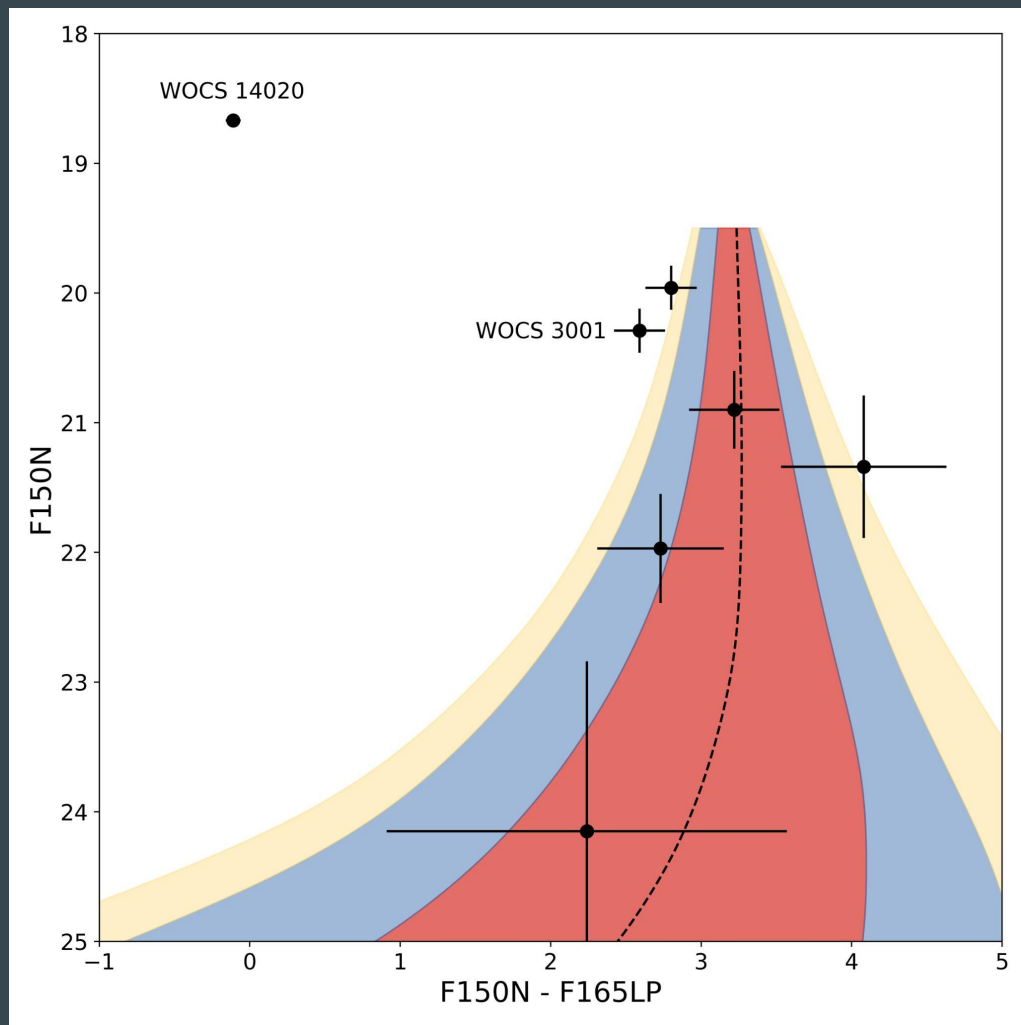
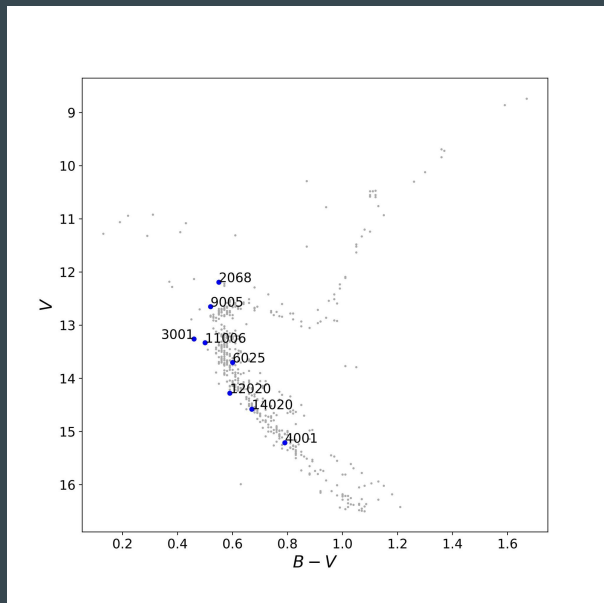
- Discovered on the main sequence of M67 (4 Gyr) by Leiner et al. (2019), as part of the ongoing WIYN Open Cluster Study (WOCS)
- Anomalously rapidly rotating stars ( $P_{\text{rot}} \sim 2\text{--}8$  days), corresponding to gyrochronological ages  $\lesssim 1$  Gyr
- Eleven blue lurkers were discovered, eight of which are in binaries ( $P_{\text{orb}} \sim 10^2\text{--}10^4$  days)



# Observations

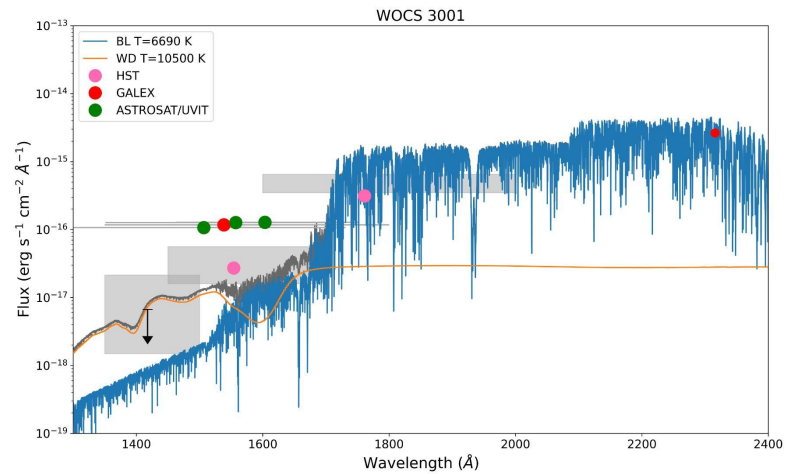
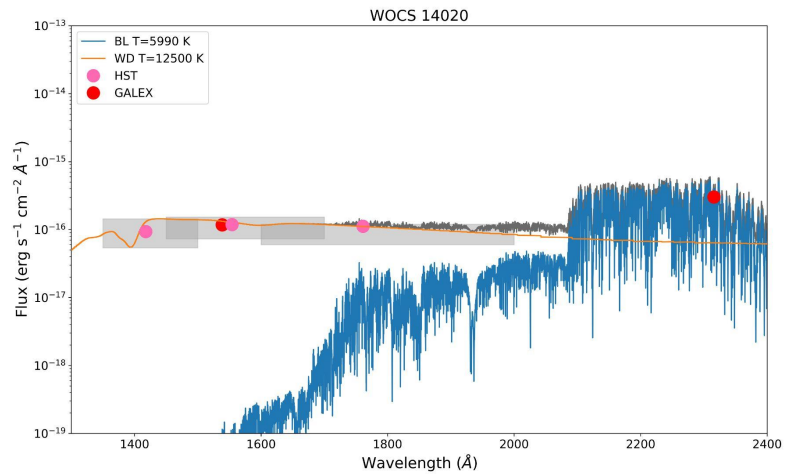
- We observed the eight binary blue lurkers with the *Hubble Space Telescope* Advanced Camera for Surveys/Solar Blind Channel (*HST* ACS/SBC)
- Observations were conducted in three FUV broadband filters: F140LP ( $\sim 1400 \text{ \AA}$ ), F150LP ( $\sim 1500 \text{ \AA}$ ), and F165LP ( $\sim 1650 \text{ \AA}$ )
- We use the nested structure of the bandpasses to derive narrowband filters: F140N (F140LP–F150LP) and F150N (F150LP–F165LP)
- Magnitudes were computed for each blue lurker using aperture photometry with a radius of  $1''$





# Blue Lurker–White Dwarf SEDs

- Blue lurker effective temperatures were derived by fitting Castelli & Kurucz (2003) model atmospheres to available optical and IR photometric measurements
  - WOCS 3001: 6690 (+80, -160) K
  - WOCS 14020: 5990 (+60, -110) K
- Generated UVBLUE (Rodríguez-Merino et al. 2005) model atmospheres for the blue lurkers at the derived effective temperatures
- Generated Koester (2010) white dwarf model atmospheres, scaled assuming a distance to M67 of 850 pc (Leiner et al. 2019) and a radius of  $1.3 \times 10^9$  cm ( $0.019 R_{\odot}$ ), corresponding to a He white dwarf mass of  $\sim 0.45 M_{\odot}$  (Pani et al. 2007)
- Found the best-fit combination of blue lurker and white dwarf models by incrementing the effective temperature of the white dwarf model to fit the available UV data



# What Does This Mean?

- Gosnell et al. (2015) detected four hot white dwarf companions to the blue stragglers of NGC 188 (7 Gyr) out of a sample of 19, corresponding to a detection rate of ~21%
- Based on the N-body simulations of NGC 188 by Geller et al. (2013), a detection of  $3.4 \pm 1.5$  white dwarfs was expected (Gosnell et al. 2014)
- We detected 2 white dwarf companions out of a sample of 8 blue lurkers, or 25%
- Based on the N-body simulation of M67 blue stragglers conducted by Hurley et al. (2002), if we were to observe 8 M67 blue stragglers at random we would expect to detect  $3.6 \pm 1.9$  hot white dwarfs
  - This assumes a maximum detectable white dwarf age of ~400 Myr
- It is plausible that all of the binary blue lurkers are products of mass transfer



# Summary

- We observed eight binary blue lurkers in the open cluster M67 with *HST*
- Out of the eight blue lurkers, we detected two white dwarf companions based on their FUV flux
- This detection rate is consistent with the expected detection rate based on similar mass-transfer products
- It is therefore plausible that the blue lurkers are low-luminosity analogues to the classical blue stragglers
- Future FUV spectroscopic observations are needed to constrain the properties of the white dwarfs

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