Researchers propose new formation model for massive hot subdwarfs

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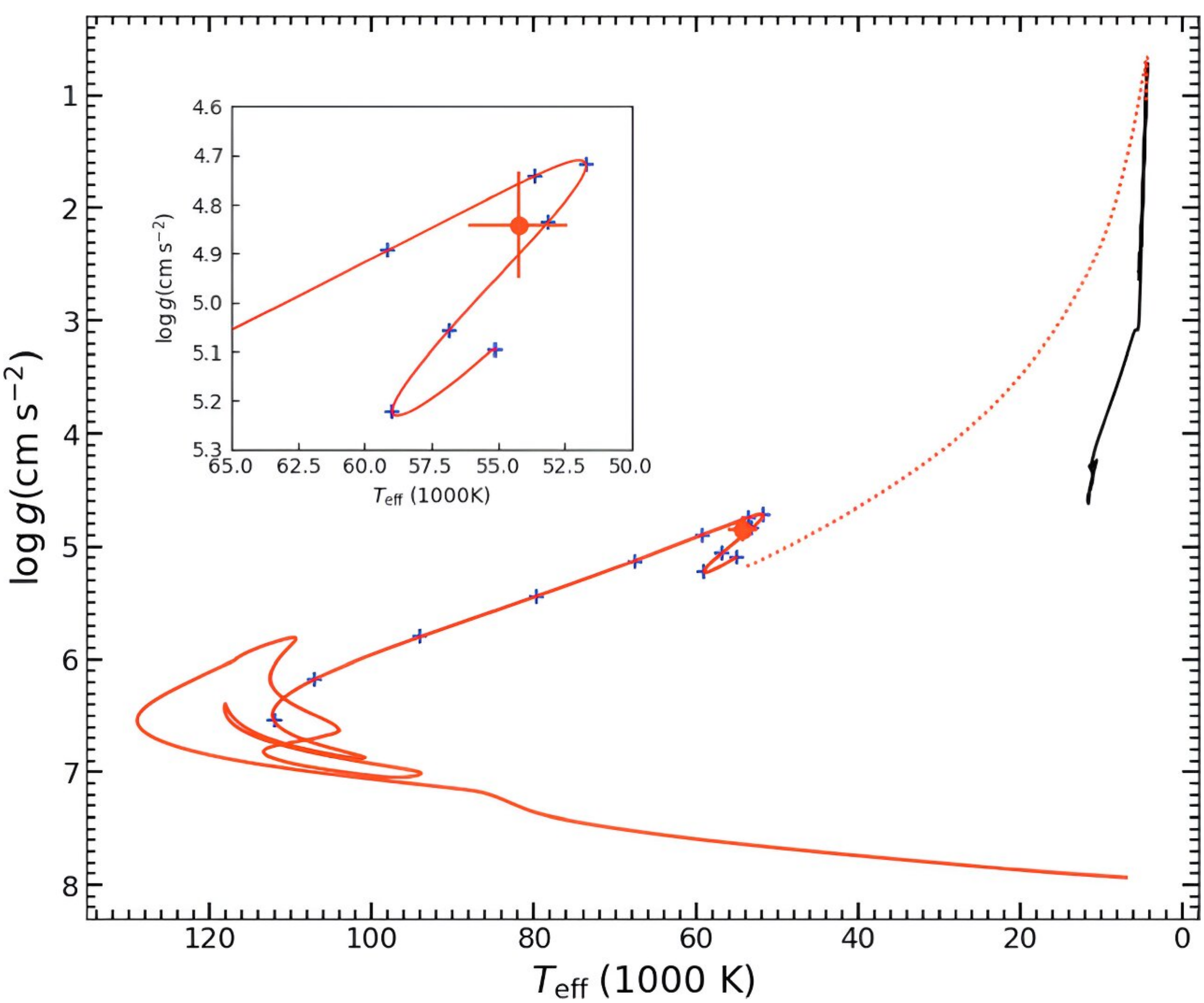

Constructing the evolutionary model of SMSS J1920. The initial progenitor mass is 1.8 $M_\odot$ with Z = 0.001. The mass of the produced sdO/B is 0.553 $M_\odot$, with an envelope mass of 0.003 $M_\odot$ and CO core mass of 0.50 $M_\odot$. The red circles are for SMSS J1920. The time intervals between adjacent pluses are 10^4 yr. Credit: *The Astrophysical Journal* (2024). DOI: 10.3847/1538-4357/ad2206

In a new study published in the *The Astrophysical Journal*, Dr. Li Zhenwei and his collaborators from Yunnan Observatories of the Chinese Academy of Sciences (CAS), and Dr. Zhang Yangyang from the Zhoukou Normal University, proposed a new formation model for massive hot subdwarfs, offering explanations for a subset of helium-rich hot subdwarfs observed in the cosmos.

Hot subdwarfs are one type of extreme horizontal branch star. Some of these stars, discovered in close binaries, are considered as potential gravitational-wave (GW) sources for future space-borne GW detectors. The distinctive chemical peculiarities, particularly the helium (He) abundance on their surfaces, serve as valuable tools for comprehending the formation and evolution of these celestial bodies.

Hot subdwarfs are generally formed through binary interactions with the ignition of the He core when the donor initiates mass transfer near the tip of red giant branch (RGB). This scenario is known as the RGB channel. However, the recent discovery of the star SMSS J1920, the third known binary consisting of a hot subdwaf star and an accreting white dwarf, is in contradiction to the RGB channel.

The strong Ca H and K lines with a blueshift suggest that the binary likely originated from the recent ejection of the common envelope (an ejection age of ~10,000 years). In contrast, for hot subdwarfs produced from the RGB channel, the time since the common envelope ejection to the current state spans several tens of millions of years.

To explain the formation of SMSS J1920, researchers proposed a new route towards hot subdwarfs. This involves a hot subdwarf produced from the common envelope ejection process with an asymptotic giant branch (AGB) star, termed the AGB channel. Unlike the hot subdwarf from an RGB star, a hot subdwarf from an AGB star contains a large carbon and oxygen (CO) core, helium-burning shells, and a hydrogen envelope.

Utilizing state-of-the-art stellar evolution code, researchers constructed the evolutionary models of the hot subdwarfs from the AGB channel. The simulated results can explain most of the important observed parameters of SMSS J1920, such as the evolutionary age, hot subdwarf mass, effective temperature and surface gravity.

The AGB channel can explain not only SMSS J1920 but also some observed special hot subdwarfs. The AGB channel could produce hot subdwarfs with masses exceeding 0.48 times the mass of the sun. In the RGB channel, however, most hot subdwarfs had masses of less than 0.48 times the mass of the sun. This suggested that a part of the massive hot subdwarfs may originate from the AGB channel.

Moreover, researchers found that hot subdwarfs from the AGB channel generally exhibit high helium (He) abundances, which can be attributed to partial hydrogen burning in the envelope. Therefore, the hot subdwarfs from the AGB channel can naturally explain a part of He-rich hot subdwarfs observed in the cosmos.

More information: Zhenwei Li et al, A New Route to Massive Hot Subdwarfs: Common Envelope Ejection from Asymptotic Giant Branch Stars, *The Astrophysical Journal* (2024). DOI:

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