

Abstract

Benchmark brown dwarfs are objects that have at least two measured fundamental quantities such as luminosity and age, and therefore can be used to test substellar atmospheric and evolutionary models. Nearby, young, loose associations such as the β Pic moving group represent some of the best regions in which to identify intermediate-age benchmark brown dwarfs due to their well-constrained ages and metallicities. We present a spectroscopic study of a new companion at the hydrogen-burning limit orbiting a low-mass star at a separation of $9''$ (650 AU) in the 23 Myr old β Pic moving group. The medium-resolution near-infrared spectrum of this companion from IRTF/SpeX shows clear signs of low surface gravity and yields an index-based spectral type of $M6\pm 1$ with a VL-G gravity on the Allers & Liu classification system. Currently, there are four known brown dwarf and giant planet companions in the β Pic moving group: HR 7329 B, PZ Tel B, β Pic b, and 51 Eri b. Depending on its exact age and accretion history, this new object may represent the third brown dwarf companion and fifth substellar companion in this association.

Empirical analysis of 2Mo443+3723B

Spectral type results from the empirical analysis using a reduced chi squared method to compare the IRTF SpeX/SXD 2Mo443+3723B spectrum with the SpeX Prism Library. A more quantitative approach using the Allers & Liu classification scheme yielded a spectral type of $M6\pm 1$ with a final gravity score of VL-G gravity which supports a young age for 2Mo443B.

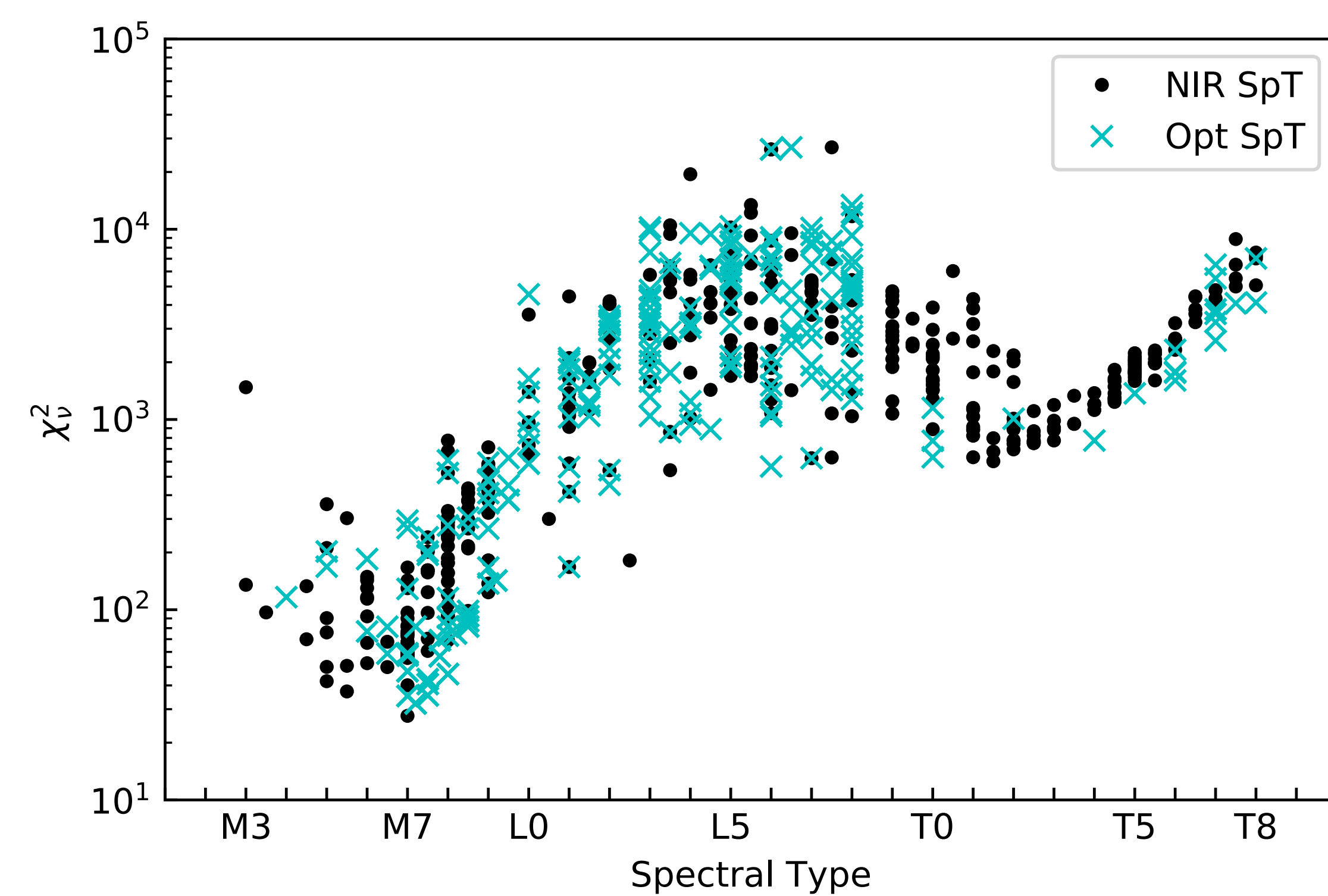


Fig 1: χ^2_r comparison between M, L, and T dwarfs in the SpeX Prism Library and 2Mo443B. Near-IR spectral types are shown in black and the optical spectral types are indicated with the blue crosses.

2Mo443+3723B: An analog to PZ Tel B?

PZ Telescopii (PZ Tel) B is an example of a benchmark brown dwarf system in the β Pic Moving Group, which was discovered with high contrast imaging. 2Mo443+3723B is an analog system to PZ Tel B. The substellar companion PZ Tel B has a separation of $0.5''$ (26 AU) from its host star PZ Tel A (Biller et al. 2010). Maire et al. (2015) studied this system using low resolution spectroscopy from the VLT/SPHERE, but the close proximity to its host star makes it challenging to characterize in detail. This analog system, 2Mo443AB, lies at a distance of 74 pc (Dahn et al. 2017) and is located farther away from its host star than PZ Tel B, so we are able to carry out a detailed analysis with high resolution spectra.

Our empirical analysis of 2Mo443B gives a spectral type of $M6\pm 1$ while Maire et al. (2015) reports a finding of $M7\pm 1$ for PZ Tel B. Maire et al. (2015) also reports a $\log L/L_\odot = -2.51 \pm 0.10$ dex with an estimated mass range of $51-72 M_J$. The initial analysis for 2Mo443B has yielded a $\log L/L_\odot = -2.12 \pm 0.003$ dex, which yields a mass that is near the hydrogen-burning limit.

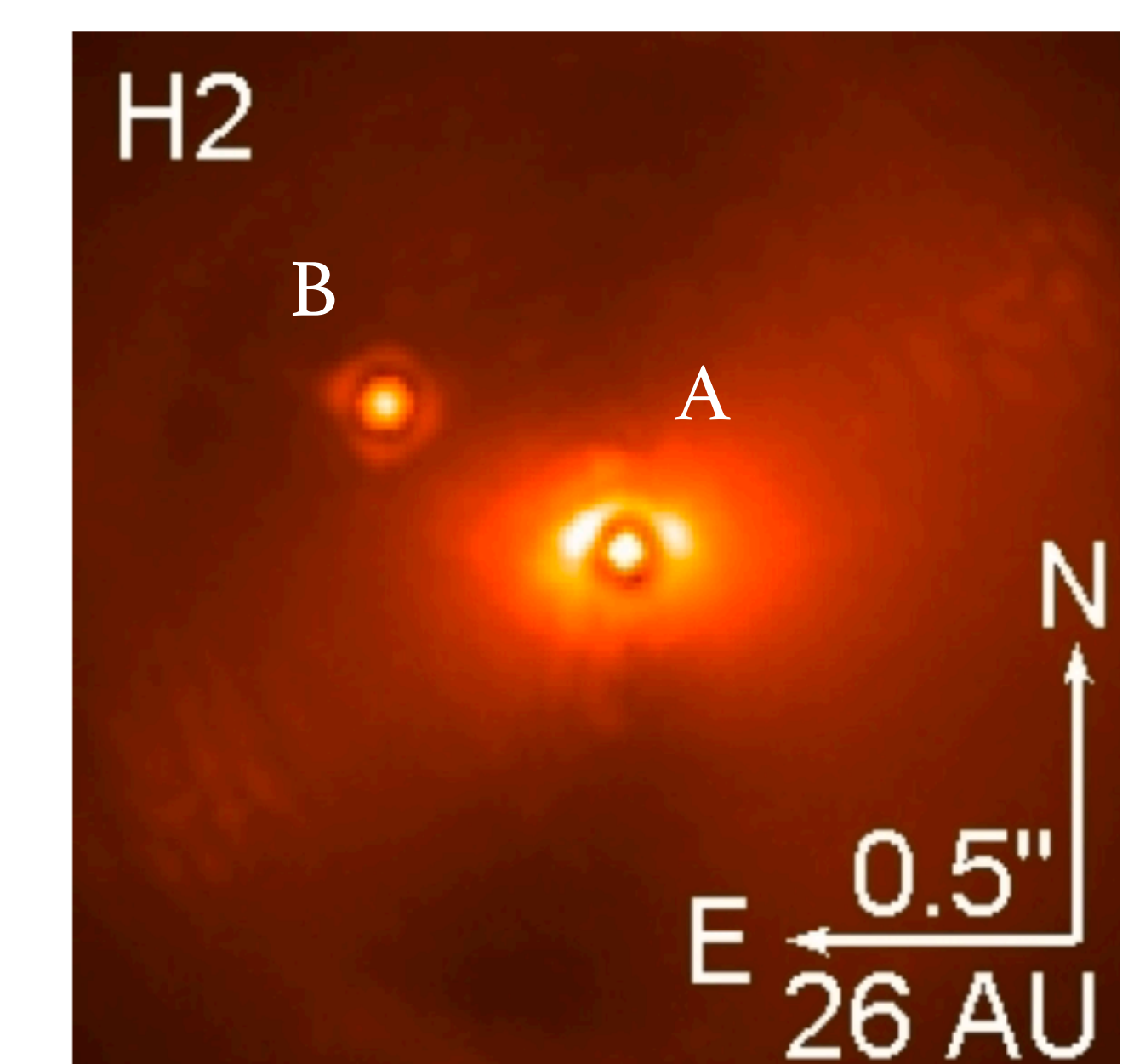
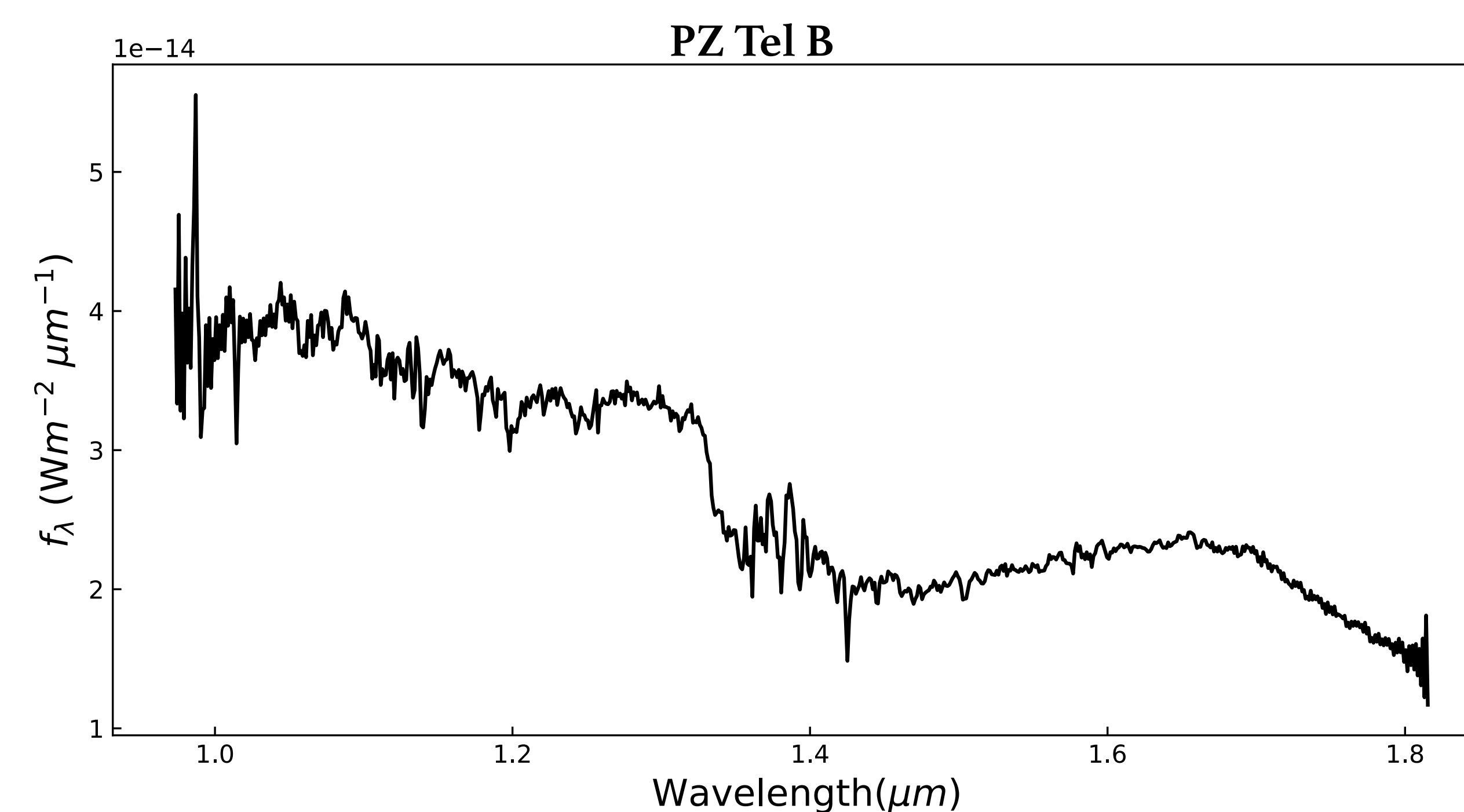
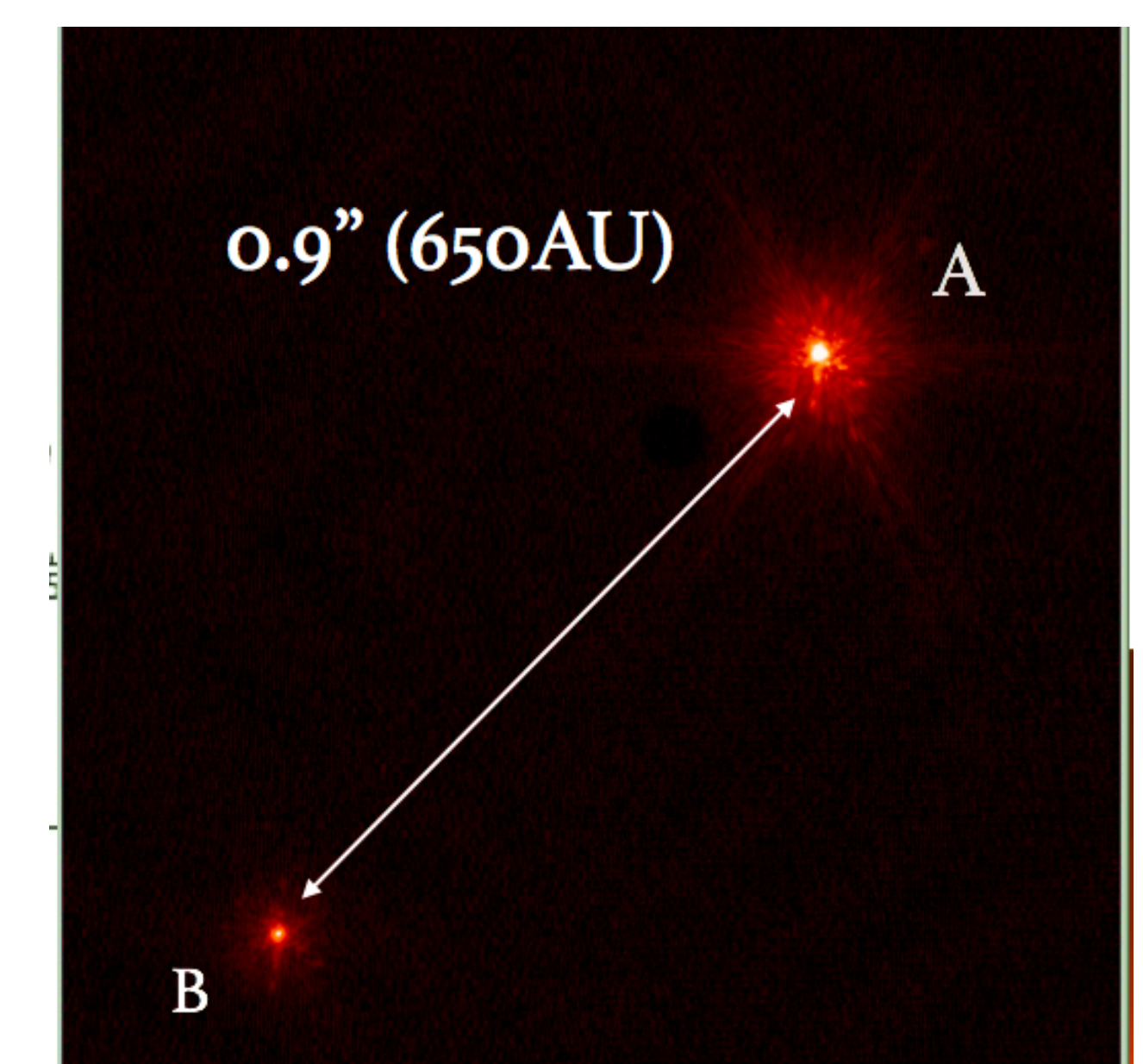
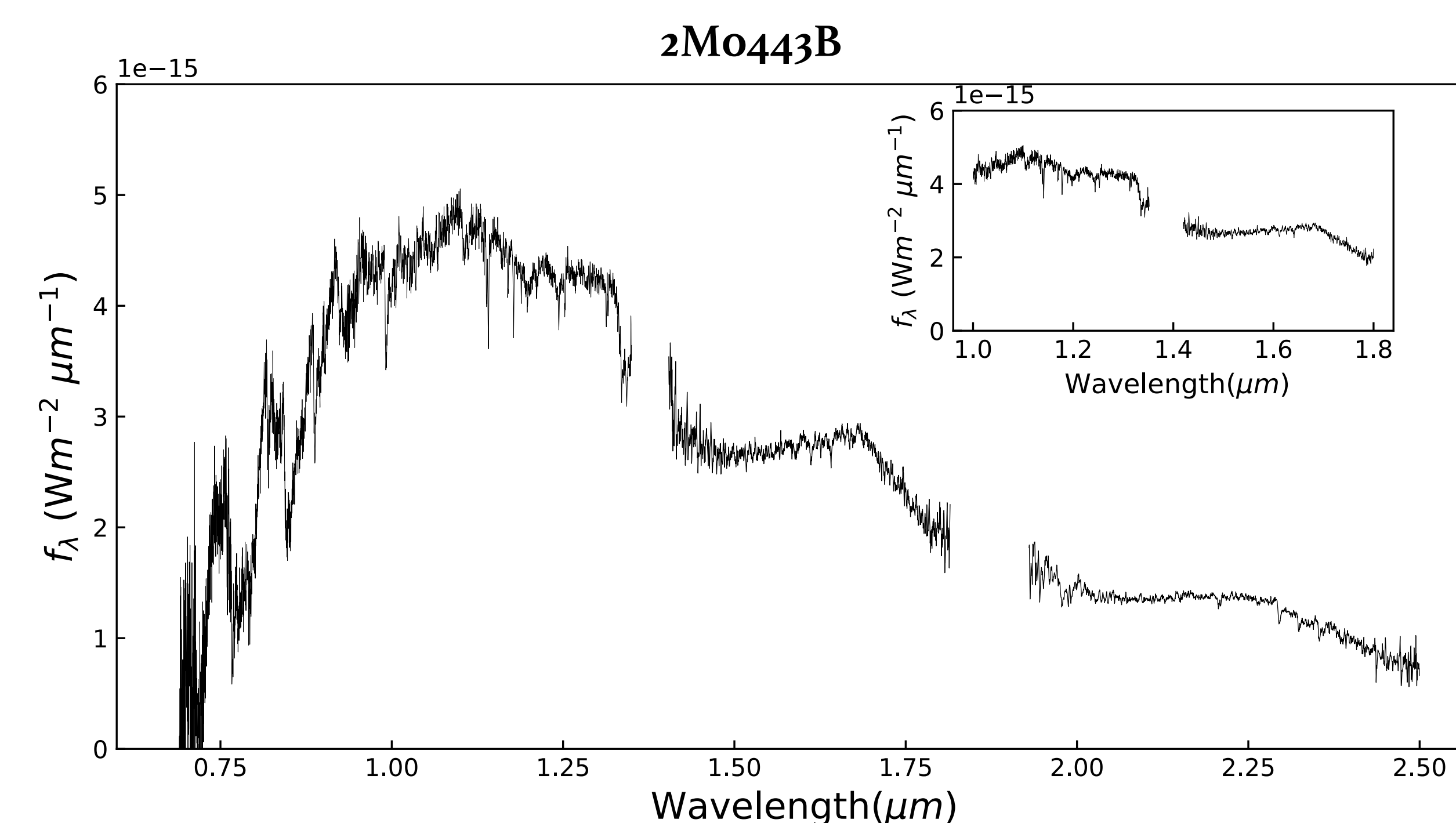


Fig 3: Comparison of PZ Tel B and suspected brown dwarf analog, 2Mo443B, in the β Pic Moving Group. **Top:** Spectrum of medium resolution 2Mo443B ($R \sim 2500$), along with the H Band NIRC2 image of the 2Mo443+3723 system. **Bottom:** Near-IR spectrum of PZ Tel B (Maire et al. 2015) along with image of the PZ Tel system in the H band filter.

Substellar companions in the β Pic Moving Group

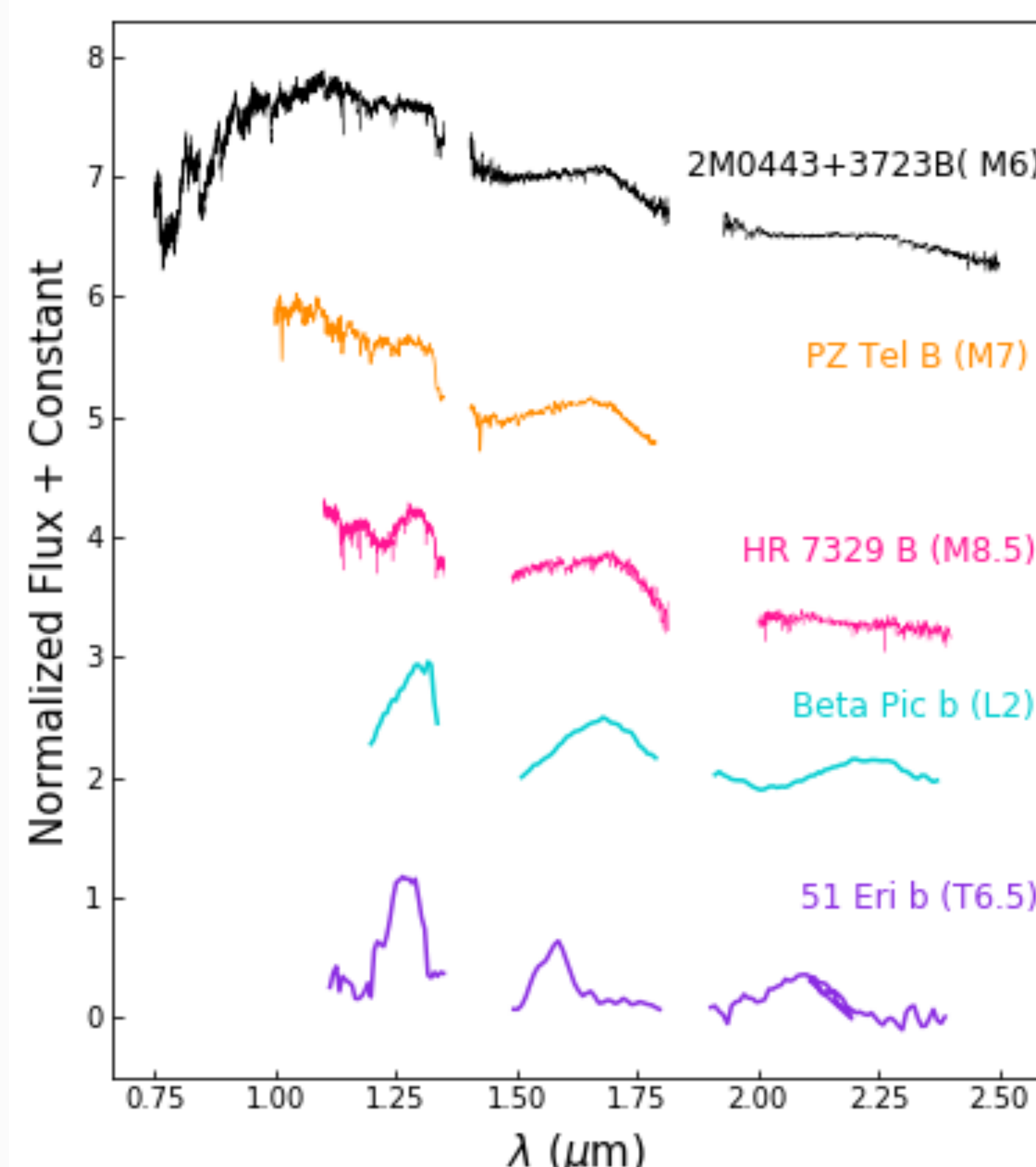


Fig 2: Sequential spectral order of known substellar companions in the BPMG along with the candidate benchmark brown dwarf, 2Mo443B.

Future Directions

2Mo443 B appears to be overluminous for its spectral type and age, especially when comparing it to PZ Tel B. This may indicate that it may be a close binary. However, our AO images of the companion from Keck/NIRC2 do not show overt signs of being a visual binary. We have also acquired a high resolution ($R=45,000$) near-infrared (1.4-2.5 micron) spectrum of the companion from the Immersion Grating Infrared Spectrometer (IGRINS) at the DCT with which we will investigate whether it is an (unresolved) spectroscopic binary. If 2Mo443 B is single, then it is likely it lies just above the hydrogen-burning limit, implying the substellar boundary lies between M6-M7 in the 23 Myr Beta Pic Moving Group.

