Precise Ages for Benchmark Brown Dwarfs HD 19467 B and HD 4747 B

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Introduction

Large uncertainty in the age of brown dwarfs, stemming from a mass-age degeneracy, makes it difficult to constrain substellar evolutionary models. To properly constrain the models, we need "benchmark" brown dwarfs, whose mass and age can be determined independently of their luminosity. HD 19467 B and HD 4747 B are two benchmark brown dwarfs detected through the TRENDS (TaRgeting bENchmark objects with Doppler Spectroscopy) high-contrast imaging program for which we have dynamical mass measurements. To constrain their ages independently through isochronal analysis, we measured the angular diameters of the host stars with interferometry using the Center for High Angular Resolution Astronomy (CHARA) Array and calculated the radii. Assuming the brown dwarfs have the same ages as their host stars, we use these results to test the accuracy of several substellar evolutionary models.

Stellar Radii Measurements and Age Estimates

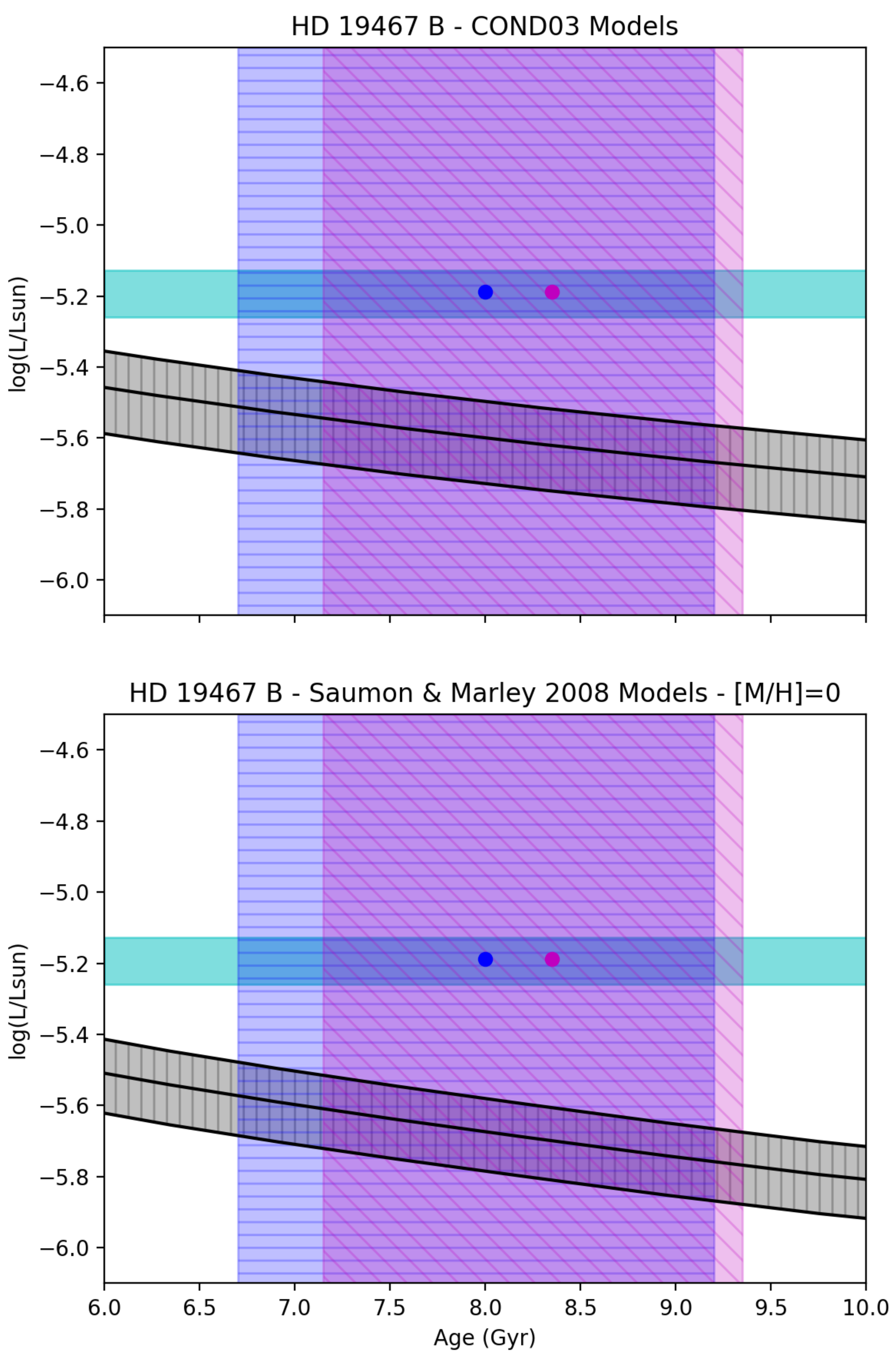
Using interferometric observations made with the CHARA Array, we obtain measurements for the disk diameters of HD 19467 A and HD 4747 A. Combined with trigonometric parallaxes from van Leeuwen (2007), we calculate the stellar radius of each star. Using the stellar radius as a fixed parameter, we are able to refine the age estimates for the two stars using the Yonsei-Yale isochrone model (Spada et al. 2013). Table 1 shows our results.

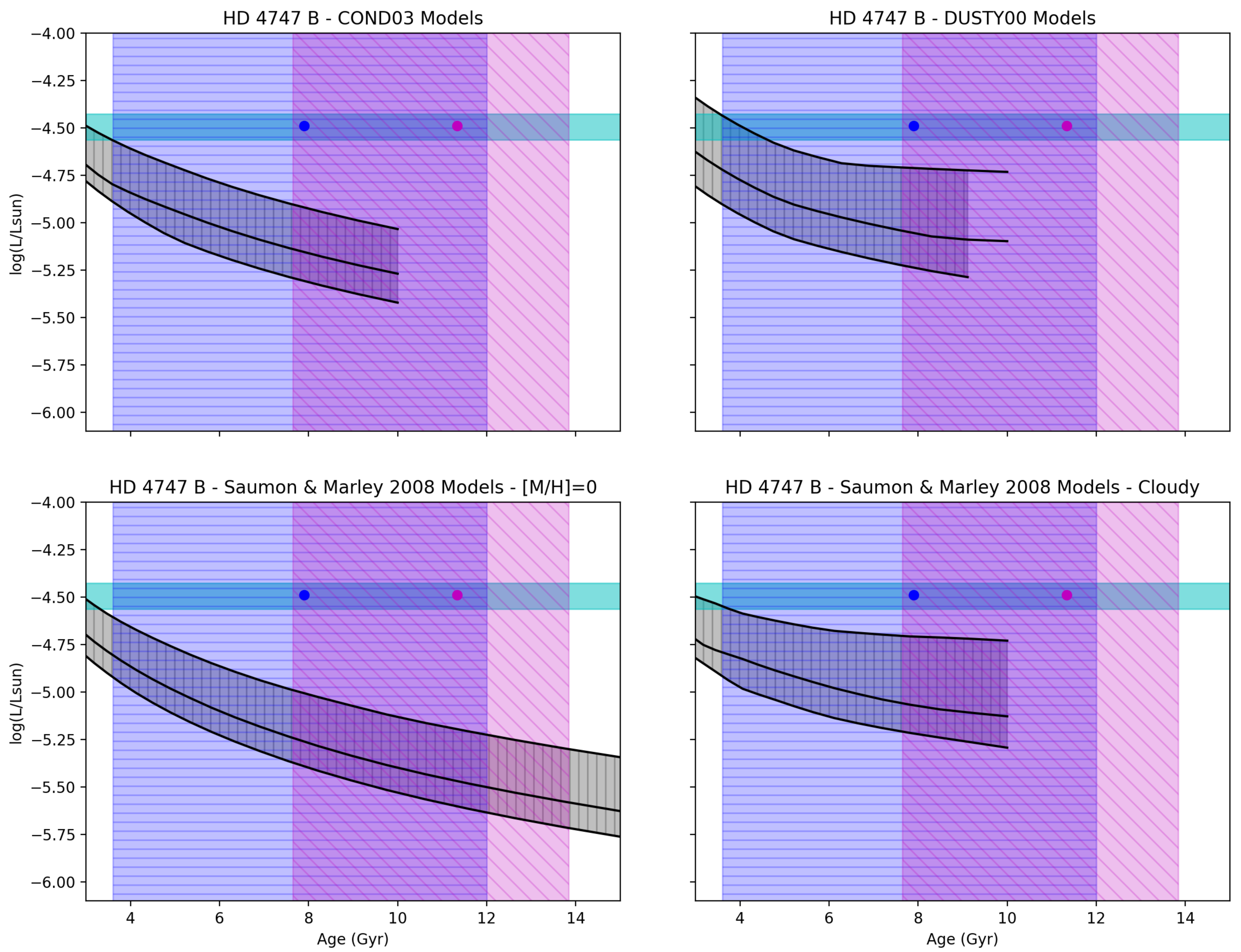
Table 1

	HD 19467 A	HD 4747 A
θ_{UD} (mas)	0.348 ± 0.010	0.363 ± 0.009
θ_{LD} (mas)	0.366 ± 0.011	0.389 ± 0.010
R ($R_\odot$)	1.214 ± 0.043	0.781 ± 0.022
Age (Gyr)	8.35 +1.0/-1.2	11.34 +2.5/-3.7

Comparison to Models

Assuming the brown dwarf companions have the same ages as their host stars, we use the refined age estimates to constrain several substellar evolutionary models (Baraffe et al. 2003, 2015; Saumon & Marley 2008). HD 4747 B is a late L-dwarf at the L/T transition where its atmosphere is cool enough to start forming clouds, so we also compare it to cloudy models (Charbrier et al. 2000; Baraffe et al. 2002; Saumon & Marley 2008).





Figures 1 & 2: Luminosity versus age for HD 19467 B (left) and HD 4747 B (right) with each substellar evolutionary model. The linearly interpolated models (black) are compared to the data for both brown dwarfs using the isochronal ages from the discovery papers (dark blue) and the refined isochronal age estimates from this work (magenta) using the measured stellar radii.

Conclusions

We find that many of the models tested under-predict the luminosity of both HD 19467 B and HD 4747 B. We cannot make conclusions about the BHAC15 models (Baraffe et al. 2015) at this time as they do not extend out to the ages we need for the given masses of the benchmark brown dwarfs. For HD 4747 B, the cloudy models tested are a better fit than the cloudless models.

In Progress Work

We are working on a Python code to numerically compare the data to the models. This code will be used to determine which of the models tested best fits the data.

We are working on obtaining age estimates using the Yale-Potsdam Stellar Isochrone model and through the Modules for Experiments in Stellar Astrophysics asteroseismology model to help remedy discrepancies between various isochronal models and between the isochronal models and gyrochronological models.

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Further questions? Email: cwood12@nd.edu

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