Characterizing White Dwarf Planetary Systems with JWST

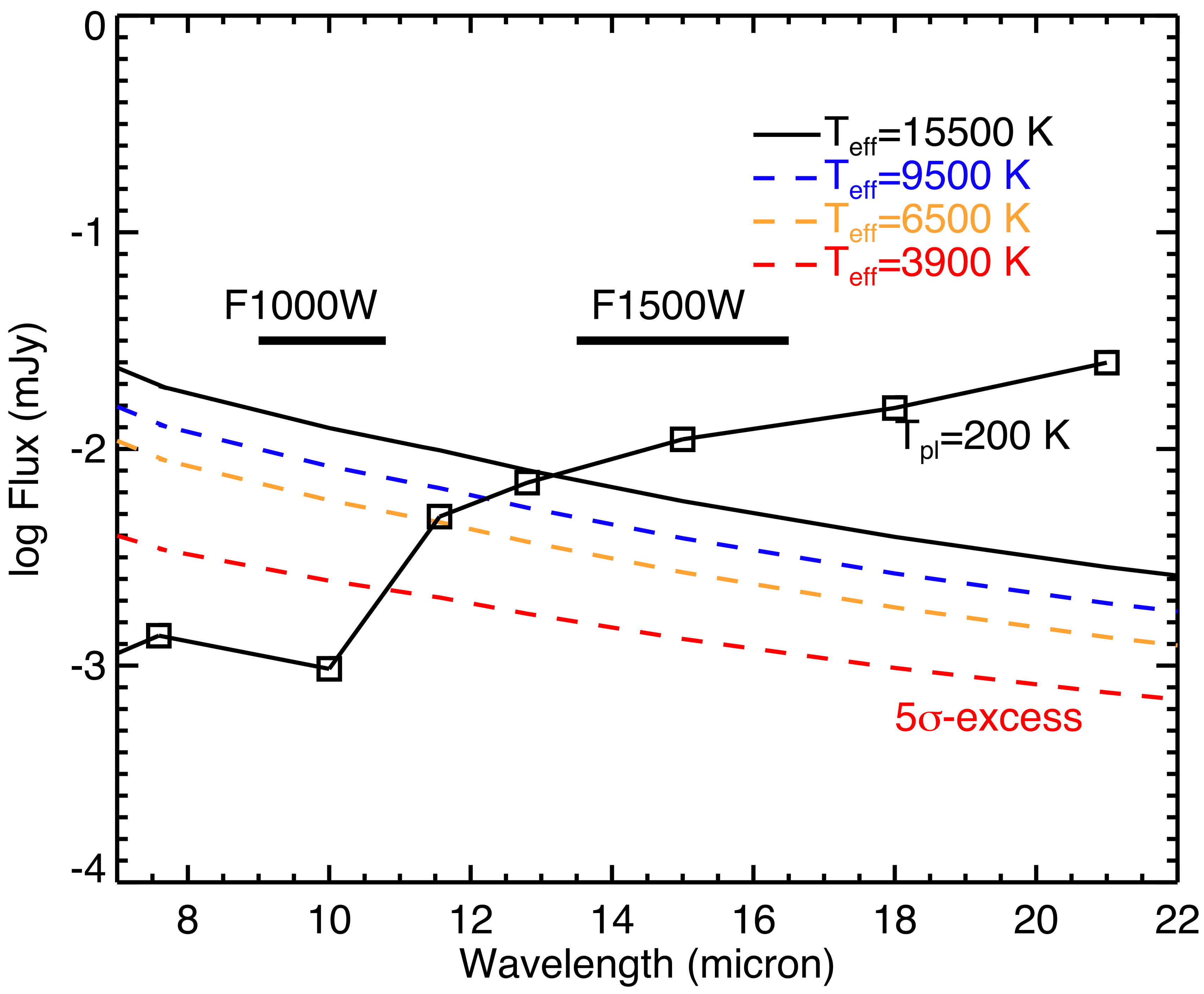
J. Debes[1], L. Rogers[2], S. Poulsen[3], S. Mullally[1], P. Dufour[4], R. J. Anslow[2], J.Sahlmann[4], A. Bonsor[2], S. Xu[6], G. Kennedy[7], S. Casewell[8], L. dos Santos[1,9] et al.

[1]Space Telescope Science Institute; [2]IoA, U. Oklahoma; U. Cambridge; [4]U. de Montréal, [5]RHEA Group for ESA, ESAC; [6]Gemini Observatory/NSF's NOIRLab; [7]U. Warwick; [8]U. Leicester; [9]STScI Fellow

Abstract

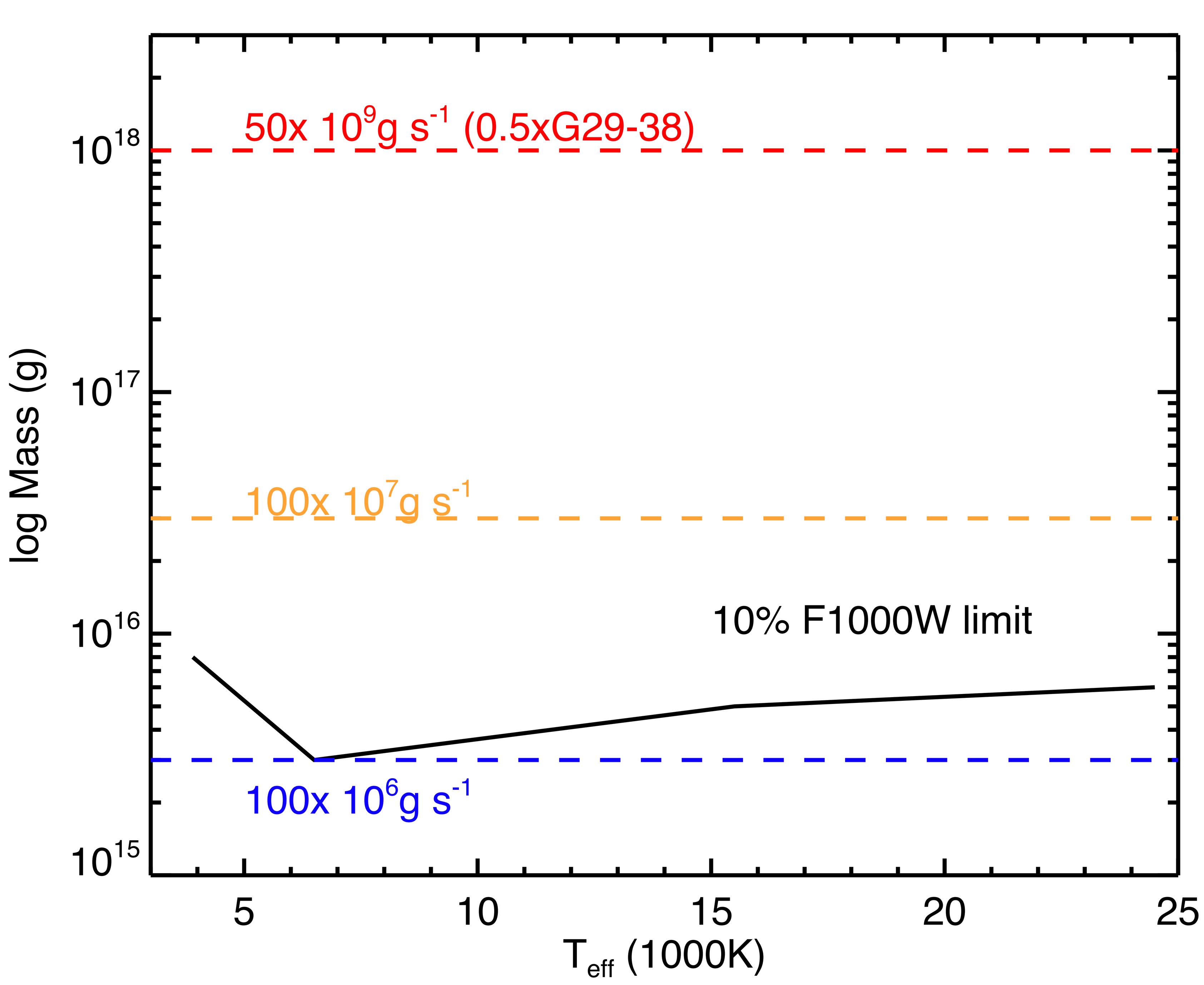
The launch of JWST has ushered in a truly unique time for the detection of planetary systems around white dwarfs, a hitherto nearly uncharted wavelength range for the large majority of nearby white dwarfs. Since 25-50% of all white dwarfs show evidence for complex planetary systems due to the pollution of their atmospheres from rocky material, they are a potentially rich population to survey in the mid-IR, where cool dust and cool exoplanets are detectable through direct imaging or against the faint photospheres of their host stars. By understanding the demographics of white dwarf planetary systems, we understand the fate of our solar system and access very cool planets hard to see around main sequence stars.

JWST can detect the thermal excess of cool planets against WD Photospheres



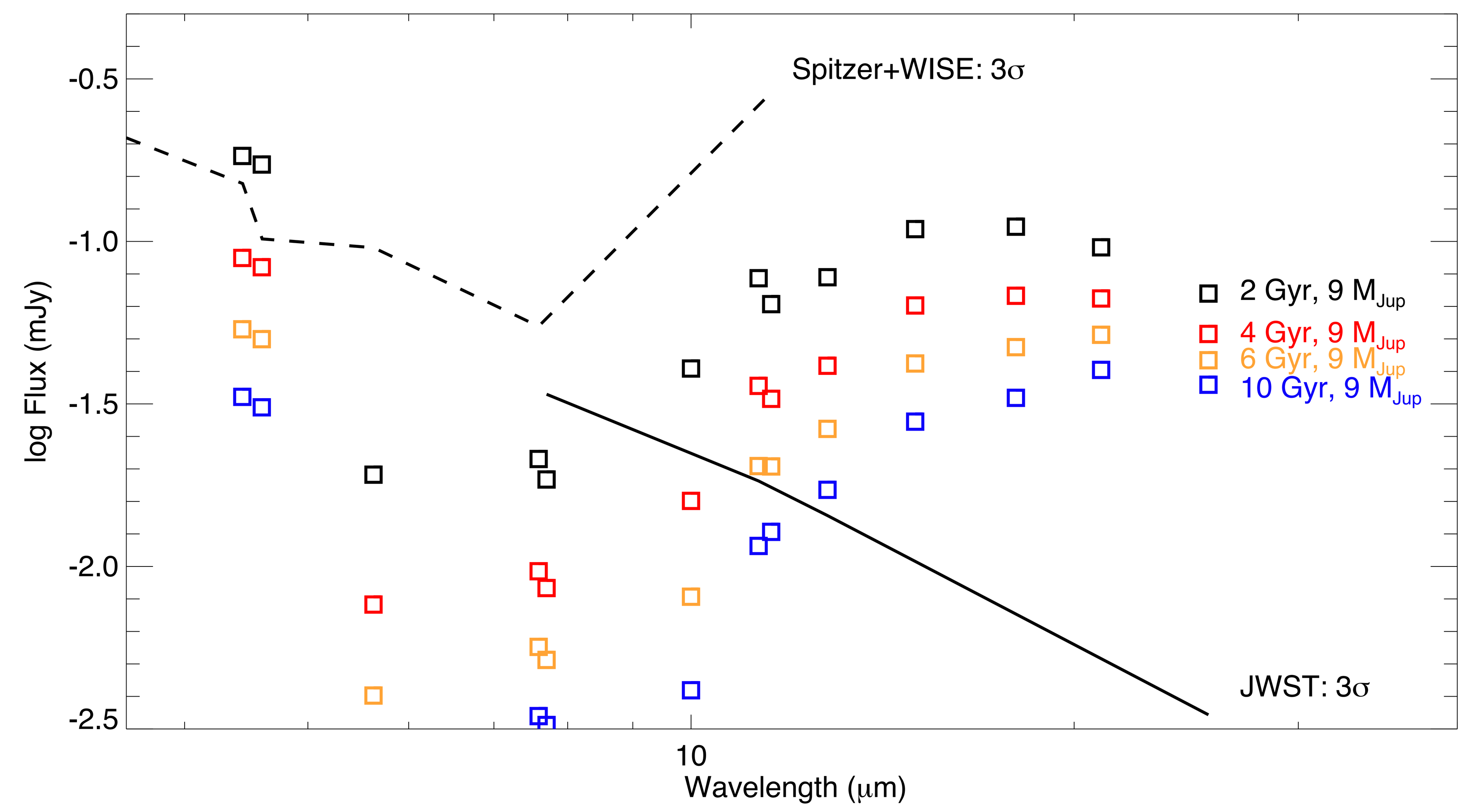
Comparison between the SED of a T_{eff}=200 K planet from the cloudless Sonora Bobcat model grid compared to predicted 5-σ flux excess limits for various WDs with temperatures that range from 3900 K and 15500 K at 10 pc. Beyond 14 μm, cool planets dominate over WDs, detectable as unresolved infrared excesses. We overplot the F1000W and F1500W bandpasses for MIRI.

JWST can detect warm and cool dust disks with very low masses



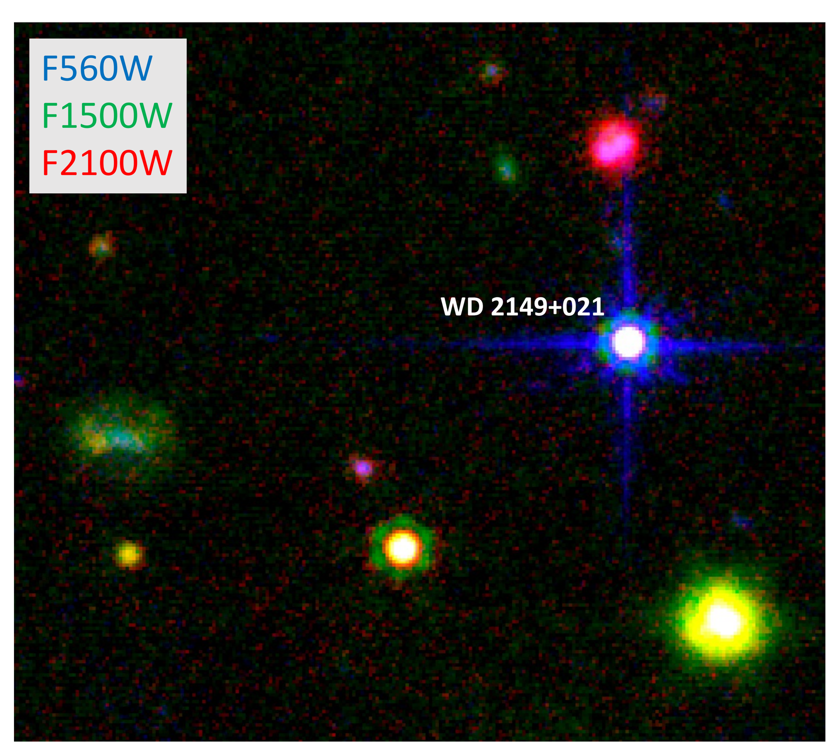
Infrared excesses can also come from cool dust disks in orbit around WDs that are actively accreting rocky material. The solid lines show JWST/MIRI's dust mass sensitivity for different dusty disks akin to those seen around G29-38 (~$2x10^{18}$; Ballering et al., 2022). Overplotted is the 10% flux excess limit as a function of white dwarf T_{eff}. Most metal rich white dwarfs accrete material at rates equivlanet to 10^6-10^{10} g/s, and JWST/MIRI will be sensitive to the dust before it's accreted.

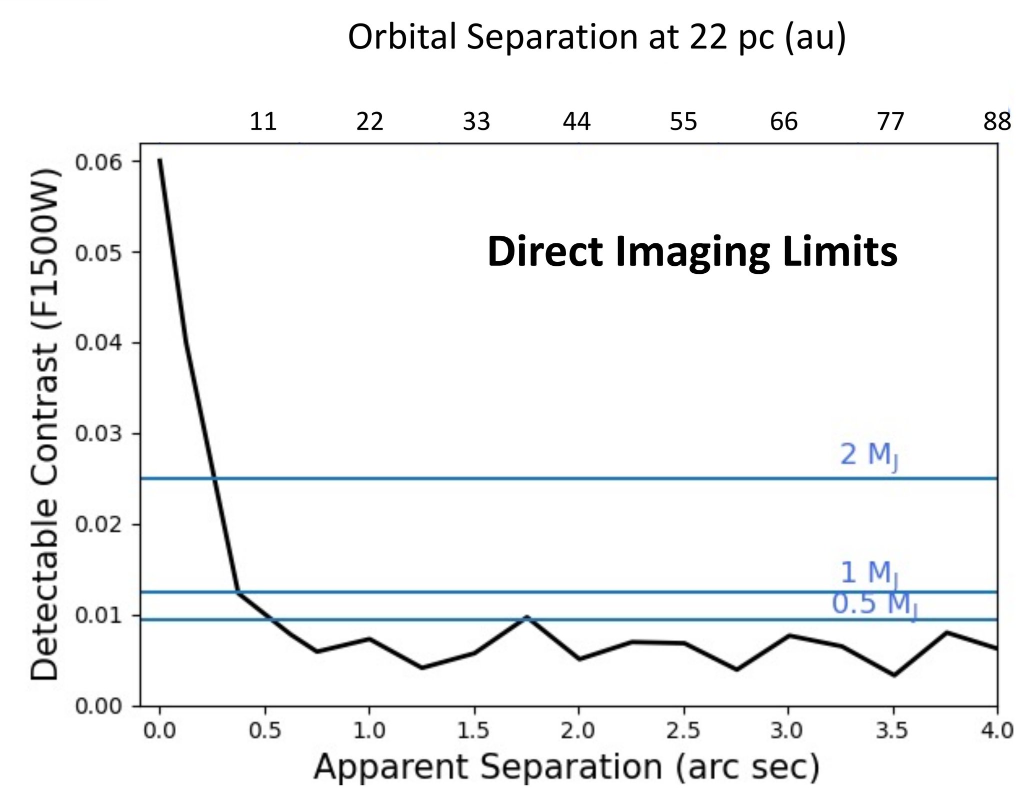
The test case of the spurious Gaia Planet WD 0141-675b

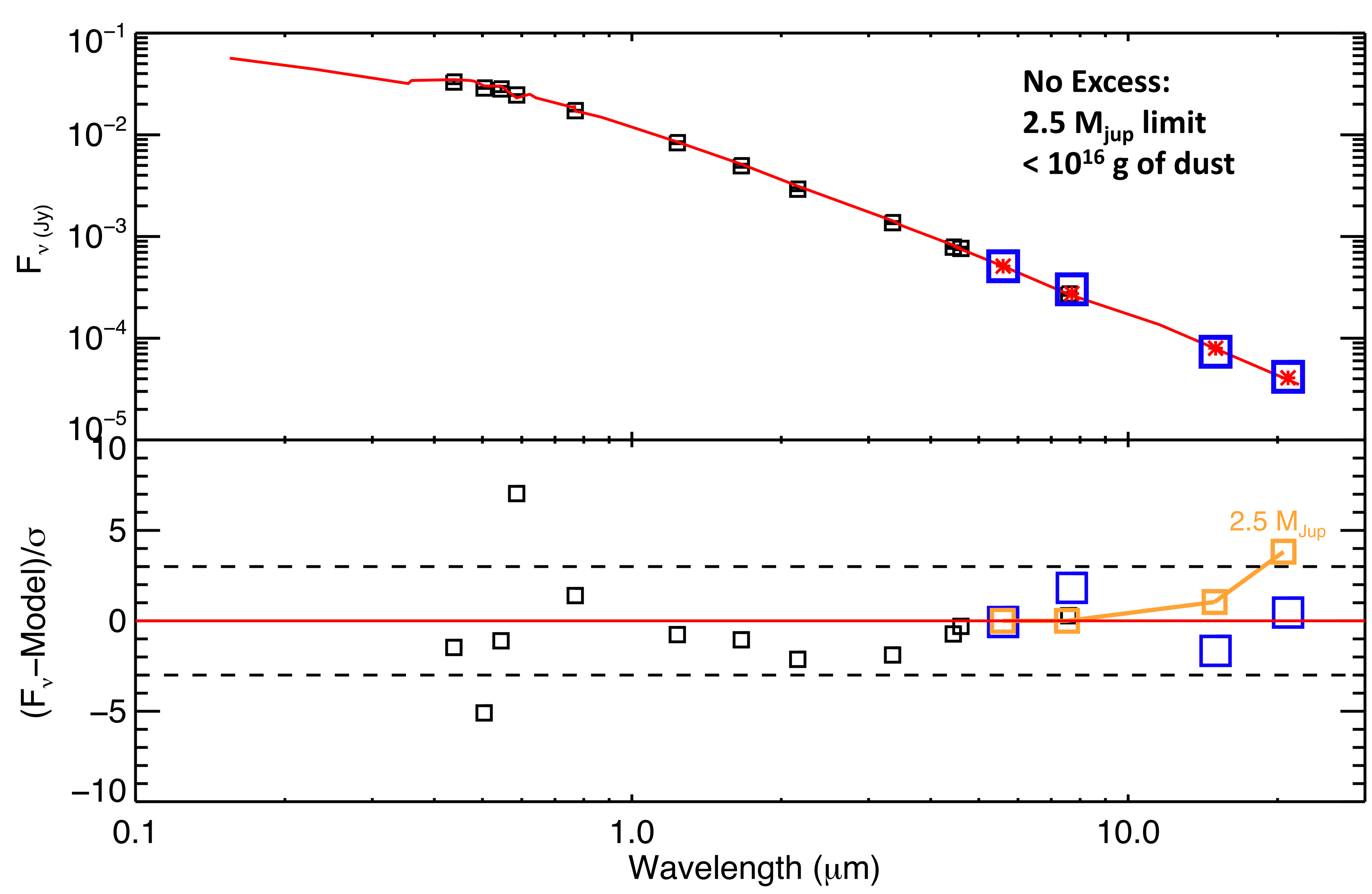


WD 0141-675 was recently reported to have a Gaia detected super-Jupiter companion that was later retracted. We show here the expected emission from such a planetary companion using Sonora-Bobcat models for planetary cooling ages between 2—10 Gyr as a function of wavelength, with 3σ upper limits from Spitzer/WISE. From these limits, a companion temperature down to 325 K is ralready uled out, equivalent to planetary cooling ages of up to 3.7 Gyr. The predicted JWST 3-σ excess limits (~6%) are additionally shown, demonstrating that with JWST/MIRI, it will be possible to detect future Gaia WD planets with ease.

First results from Program 1911: Deep limits to dust and planets around WD 2149+021







BREAKING NEWS: JWST Cycle 2 has 2 Surveys sensitive to Planets/Dust around WDs: The MEOW survey (PIs:Vanderberg, Limbach) and the MEAD Survey (PIs:Poulsen, Debes)