Searching for Dyson pheres using Gaia and WISE

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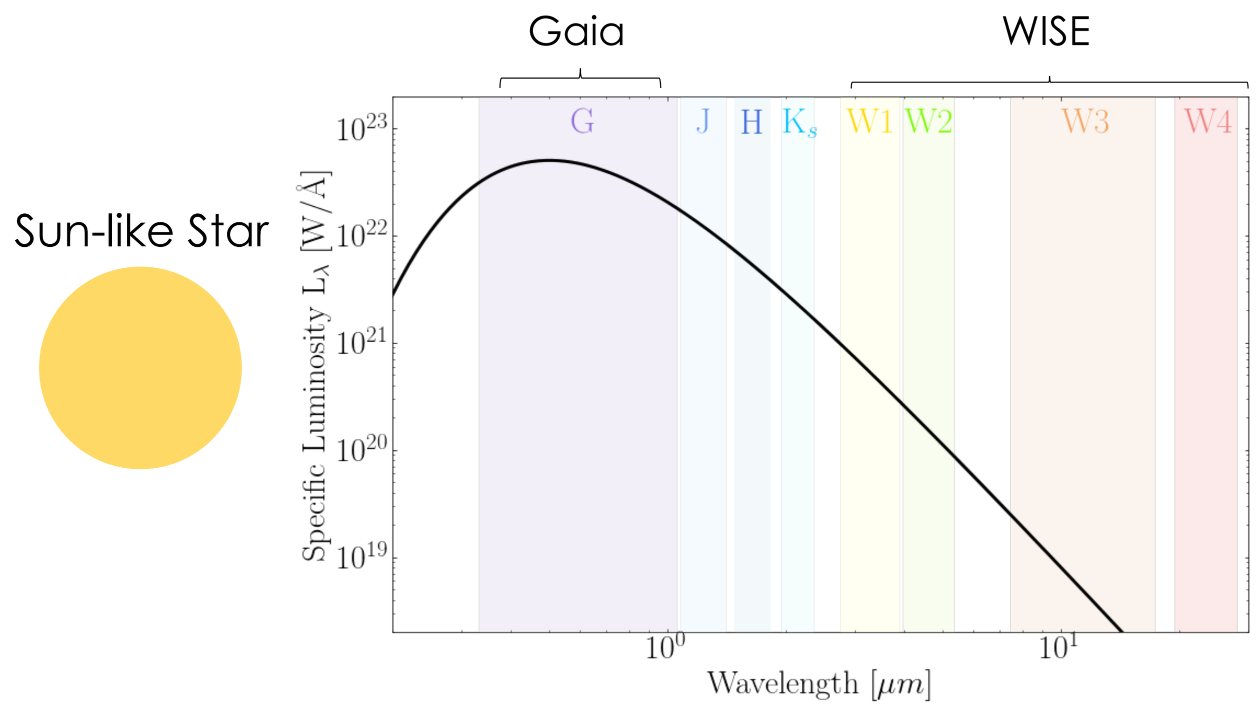
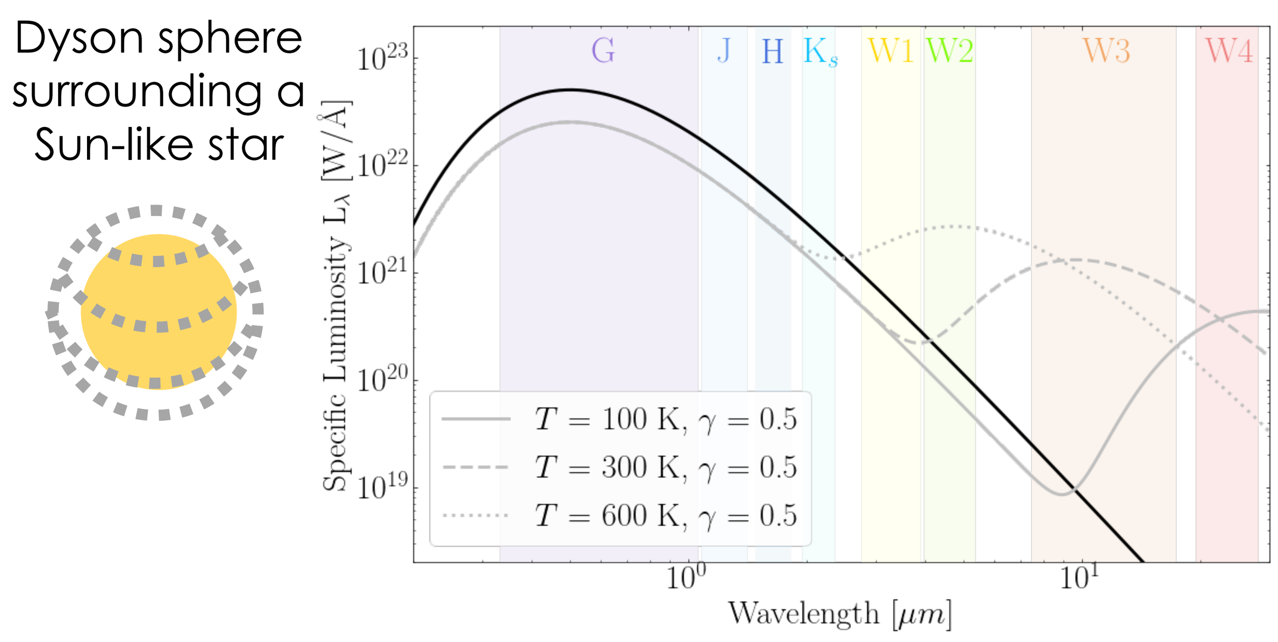
Introduction

Dyson spheres are hypothetical structures that high-level civilizations may build to harvest energy in the form of starlight. As in any thermodynamic process, the conversion of stellar energy would involve the emission of waste heat. For Dyson spheres operating at temperatures in the range 100 - 1000 K, this energy would be emitted primarily in the mid-infrared. Here we present some models to estimate upper limits on the prevalence of Dyson spheres in the Milky Way based on the number of sources with mid-infrared excess. In the present analysis, we are only using 260,000 of the most nearby stars from the Gaia DR2 and AllWISE combined dataset, but the full search will include 10^7 - 10^8 objects, making it the largest search for Dyson spheres in the Milky Way carried out so far.

The Approach

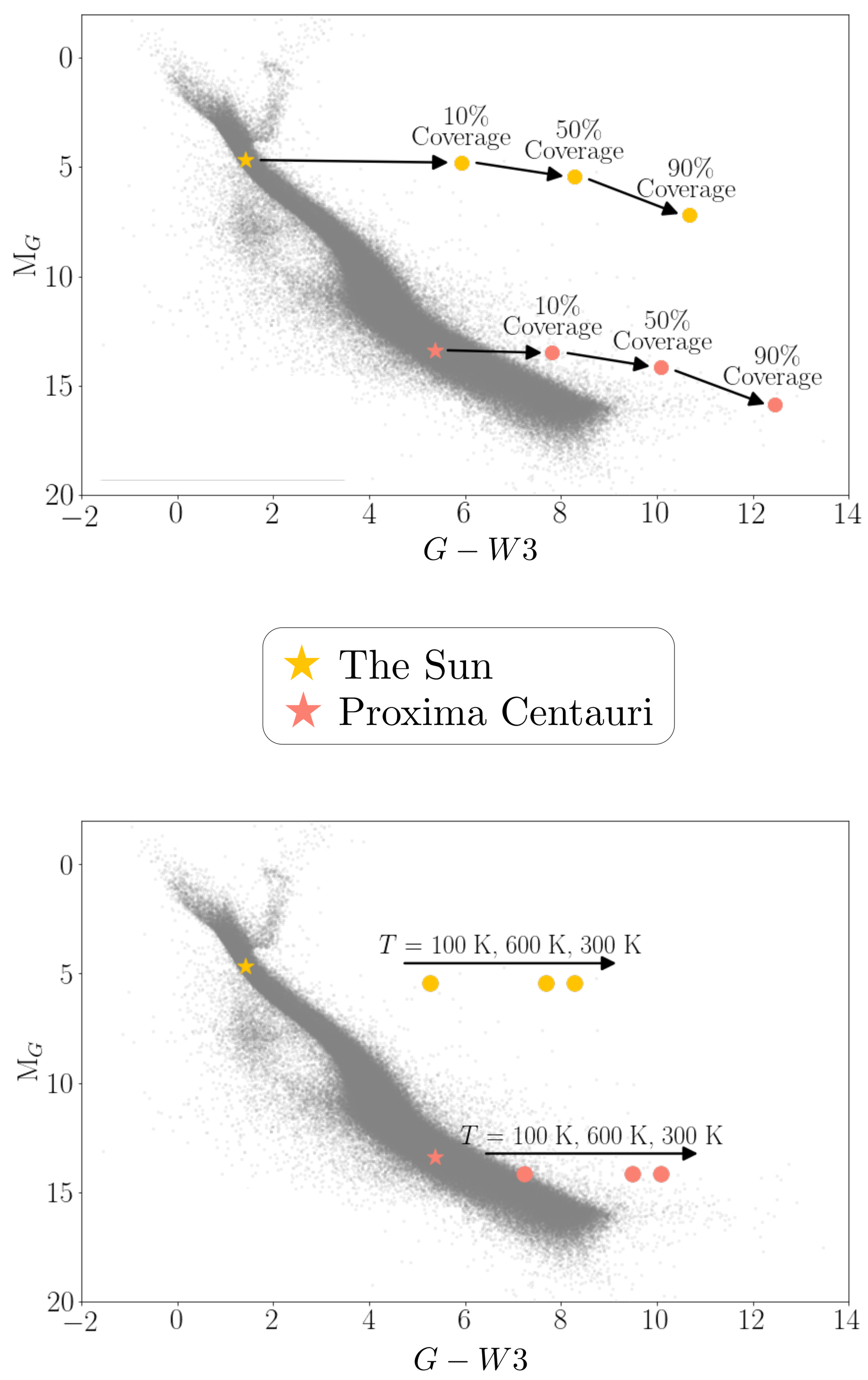




We applied Dyson sphere (DS) models to all the stars within 100 pc in the Gaia + WISE sample (~260,000 stars). The DS models consist of blackbodies that depend on two parameters: Temperature (T) and Covering factor (γ). The latter is here assumed to be the fraction of energy that the DS is re-emitting from the star.

In the left panels, we show how the spectrum of a solar-like blackbody ($T \sim$ 5800 K) changes when a Dyson sphere model is applied. We can see the boost in the mid-infrared radiation for DS with temperatures in the range 100 - 600 K, and the drop in the optical flux. Both features should be observed in the combined data Gaia and WISE data.

In the right panels, we show how a star hosting a DS may appear in the *G,G-W3* color-magnitude diagram. Different DS models for a solar-type star (orange circles), and a Proxima Centauri-type star (red circles) are shown as an example. We can see how the color is shifted towards redder regions of the diagram, and how the parameters of the DS affect this displacement in the diagram.



Models and results

The aforementioned model was applied to all the stars in the Gaia + WISE sample. We used a range of Dyson sphere temperatures between 30 - 1000 K, and a range of covering factors between 10^{-4} and 0.95. The figure shows how the stars of the sample (gray dots) would shift if they would host a DS with T = 300 K, and γ = 0.95 (orange dots). The purple line represents the boundary between our original sample and the model of stars with DS. This line was defined by fitting a straight line to the middle points created by averaging both sets. We also applied a Support Vector Machine algorithm to find the boundary for a smaller set of T and γ, The final results do not differ significantly.

For every single combination of parameters *(T, γ)* we count the number of stars in the respective candidates region. The fraction of candidates as a function of T and γ is presented below (recall that the total number of stars in the sample is ~260,000). We demand objects to have excesses in both W3 and W4 bands to qualify as DS candidates. **Conclusion: Assuming T = 300 K and γ > 0.9, less than 1 in 10,000 stars displays the mid-IR excess expected for a Dyson sphere. In this small sample, all the high-γ candidates can, however, be rejected as real Dyson spheres using auxiliary data (other than Gaia and WISE photometry).**