Stellar Metamorphosis: Proxima Centauri, Luyten's Star, Trappist-1 on the Wolynski-Taylor Diagram

Jeffrey J. Wolynski
Jeffrey.wolynski@yahoo.com
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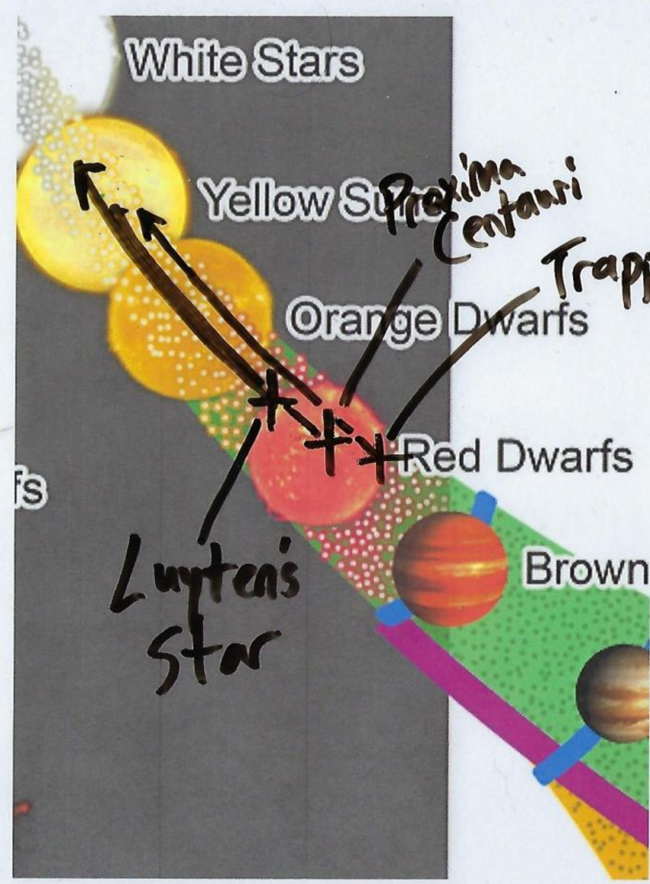
Rockledge, FL 32955

Abstract: Total axial angular momentum can be higher for an older star even though it is less massive, as this relays the fact that it sits on a higher transformation curve. A diagram is presented with calculations that give possible locations for Proxima Centauri, Luyten's Star and Trappist-1 on the Wolynski-Taylor Diagram.

Trappist-1 will form the heaviest Earth-like object out of the three stars. Proxima Centauri will form an average sized Earth, and Luyten's star will be a bit smaller. We can infer this by their previous phase curves, and their total current axial angular momentums. Trappist-1 was also much larger and heavier when it was on the same phase curve as Luyten's Star and Proxima Centauri. This is inferred because angular momentum is a conserved quantity, it simply spins at a higher rate than does Luyten's Star and Proxima Centauri, and has a comparable mass. All three red dwarf stars are younger than Jupiter, and have a few hundred more million years to collapse and lose mass to resemble Jupiter. There is still much more to work out, but this paper serves as a starting point for placing stars with considerable axial angular momentums greater than Jupiter on the WT diagram. This will be useful in the future to begin pointing out how evolved they will eventually become, and if they one day will host life on their surfaces. They are all above the Taylor Threshold, and have lots of potential. It is also important to note that angular momentum and mass are conserved quantities, it takes removal of angular momentum for it to drop, as well, mass takes mass loss for the total mass to drop. They just don't appear and disappear out of thin air.



7/6/19
– [illegible]

– Total axial angular momentum can be higher for an older star, all that means is it sits on a higher transformation curve.

Luyten's star M3.5V 116 days Red dwarf 7/5/19
(GJ 273) - BJW

Mass = .26 sun $(1.989 \times 10^{30}\, kg)$
radius .35 sun $(695.51 \times 10^{6}\, m)$

$$\omega = \frac{2\pi \text{ rad}}{\text{sec}} = \frac{6.283 \text{ rad}}{116(24)(60)(60) \text{ seconds}} = \frac{6.283 \text{ rad}}{1.002 \times 10^{7} \text{ sec}}$$

$$I = \frac{2}{5}(5.17 \times 10^{29}\, kg) \cdot (243.43 \times 10^{6}\, m)^2$$

$$I = \frac{2}{5}(5.17 \times 10^{29}\, kg) \cdot (5.9258 \times 10^{16})$$

$$I = \frac{2}{5}(5.17 \times 10^{45})\, kg \cdot m^2$$

$$I = 2.068 \times 10^{45}\, kg \cdot m^2$$

$$L = 2.068 \times 10^{45}\, kg \cdot m^2 \cdot 6.2704 \times 10^{-7}\, rad \cdot s^{-1}$$

$$L = 12.96 \times 10^{38}\, kg \cdot m^2 \cdot s^{-1}$$

$$L = 1.296 \times 10^{39}\, kg \cdot m^2 \cdot s^{-1}$$

Gyrochronology 7/6/19

It is not the rotational velocity that can determine the age of a star, It is its total axial angular momentum.

very high total axial angular momentum = very young
very low total axial angular momentum = very old

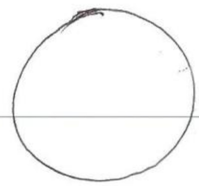
There are exceptions though, due to different stars being on different transformation curves.

A star like Trappist-1 is on a higher transformation curve, so as it evolves it will form a much larger end-result Jupiter (given same phase curve)

Total ^Axial^ Angular Momentum -JJW 7/5/19

4.49
12.96
~~902.37~~ 9,023.7

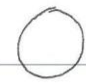
Luyter's star



$1.296 \times 10^{39}\ kg \cdot m^2 \cdot s^{-1}$

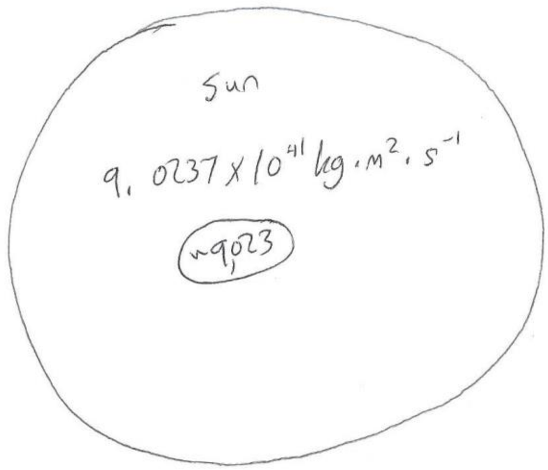
(~13)

Jupiter



$4.49 \times 10^{38}\ kg \cdot m^2 \cdot s^{-1}$

(4.5)



Radial velocity (~~Tangential velocity~~)
(rotational velocity)

Sun	Luytens Star	Jupiter
~30 days	~116 days	~10 hours

Sun to Luytens star, rate of collapse is slow alongside mass loss

Luyter's star to Jupiter, rate of collapse is faster than mass loss

The red dwarf collapsing causes it to start rotating faster, due to conservation of angular momentum, and its collapsing causes it to flare out.

Proxima Centauri M5.5Ve 7/6/19 JJW

~~≈80~~ days rotation rate 82.6 days

mass .1221 Sun $(1.989 \times 10^{30} kg)$ $(2.4 \times 10^{29} kg)$

radius = .1542 Sun $(695.51 \times 10^{6} m)$ $(107.24 \times 10^{6} m)$

$$\omega = \frac{6.283 \text{ rad}}{82.6(24)(60)(60)} = \frac{6.283 \text{ rad}}{7.136 \times 10^{6} \text{ sec}}$$

$$I = \frac{2}{5}\left(2.4 \times 10^{29} kg\right) \cdot \left(107.24 \times 10^{6}\right)^{2} \quad 11{,}500 \times 10^{12} \quad \left(1.15 \times 10^{16}\right)$$

$$I = \frac{2}{5}\left(2.4 \times 10^{29} kg\right) \cdot \left(1.15 \times 10^{16}\right) m = 1.104 \times 10^{45} \, kg \cdot m^{2}$$

$$\frac{6.283 \text{ rad}}{7.136 \times 10^{6} \text{ sec}} \cdot 1.104 \times 10^{45} \, kg \cdot m^{2} =$$

$$.88 \times \cancel{10^{6}} \text{ rad/sec} \cdot 1.104 \times \cancel{10^{45}} \, kgm^{2} =$$

$$.88 \text{ rad/sec} \cdot 1.104 \times 10^{39} \, kg \cdot m^{2} = .97 \times 10^{39} \, kg \cdot m^{2} \cdot s^{-1}$$

$$L = 9.7 \times 10^{38} \, kg \cdot m^{2} \cdot s^{-1}$$

Trappist-1   7/6/19   JJW

3.295 days rotation rate

mass .089 $_\odot$ $.177 \times 10^{30}$ kg $= 1.77 \times 10^{29}$ kg

radius .121 $_\odot$ 84.156×10^6 m $= 8.4156 \times 10^7$ m

$$\omega = \frac{6.283 \text{ rad}}{3.295(24)(60)(60)} = \frac{6.283 \text{ rad}}{2.847 \times 10^5}$$

$$I = \frac{2}{5}\left(1.77 \times 10^{29} \text{kg}\right) \cdot \left(8.4156 \times 10^7 \text{m}\right)^2$$

$$I = \frac{2}{5}\left(1.77 \times 10^{29} \text{kg}\right) \cdot \left(70.82 \times 10^{14} \text{m}\right)$$

$$I = \left(7.08 \times 10^{28} \text{kg}\right) \cdot \left(7.082 \times 10^{15} \text{m}\right)$$

$$I = 50.14 \times 10^{43} \text{kg} = 5.014 \times 10^{44} \text{kg} \cdot \text{m}^2$$

$$L = 2.207 \times 10^{-5} \text{ rad/sec} \cdot 5.014 \times 10^{44} \text{kg} \cdot \text{m}^2$$

$$11.066 \times 10^{39} \text{ kg} \cdot \text{m}^2 \cdot \text{s}^{-1} =$$

$$L = \underline{1.1066 \times 10^{40} \text{ kg} \cdot \text{m}^2 \cdot \text{s}^{-1}}$$