Separated at Birth – When is a Solar Twin Really a Twin: The Coronal and Chromospheric Properties of Optically Selected Solar Analogs and Twins

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Abstract

We have examined the X-ray, EUV, FUV, and UV properties of optically selected analogs of the Sun. The optical selection of solar analogs and twins comes chiefly from spectral and photometric criteria such as spectral types, $B-V$ indices, and absolute magnitudes. In selecting stars as analogs of the Sun, known members of interacting binaries are excluded, but stars that are members of a wide (non-interacting) binary or multiple star system (such as α Cen A) are included. For the most part, the solar proxies in our sample have spectral types that range from about G0 V to G5 V (or have $B-V$ indices between about +0.60 and +0.70). Several of these stars appear in lists of stars well-matched to the Sun – including the well-known nearby "solar twin" candidates HD 44592 (=HR 2290), 18 Sco, 16 Cyg A & B, and α Cen A. When possible, the stars are compared to the energy distributions and emission fluxes of the present Sun in the X-ray, EUV, FUV, UV, and also in the microwave region in a few cases.

Stars that appear well-matched to the Sun in the optical sometimes show stronger coronal and chromospheric emission than the Sun. This enhanced coronal and chromospheric activity arises from the more rapid rotation due to younger ages. However, the study of time-dependence of solar activity using solar proxies with known ages and rotation rates provides a "time machine" to investigate and understand the past, present, and expected future behavior of the Sun and solar magnetic activity. It also puts tighter constraints on the present Sun's place among solar type stars.

Discussion following Ed Guinan's talk

Lockwood: I wanted to say that 18 Sco is on our Solar-Stellar Spectrograph program here at Lowell, and if we can keep observing it for another 10 years, we'll tell you if it has an activity cycle or not. We've been getting it every clear night, several nights a month.

Guinan: Yes, we started observing it as well with an APT in June, and I imagine that Greg is observing it too...

Henry: We are.

Giampapa: You had red spectra of a number of these stars, with a whole range of activity levels. But taking a devil's advocate point of view, you could argue that the activity is such a small fraction of the star's bolometric flux, you could just ignore it in terms of determining what is a solar analog, and simply look at photospheric lines.

Guinan: Well, I claim they're solar analogs, but I don't claim they're solar *twins.* They're just younger Suns. As far as the twin issue goes, let me put it this way: would you want to live around a ZAMS Sun?

Giampapa: X-rays thermalize fairly high in the Earth's atmosphere.

Guinan: But the UV, the flares would be nasty.

Giampapa: So you'd have a lot of static on the radio [laughter].

Guinan: I claim, for a twin, that I want it to be the *same age* as the Sun. For an analog, I let the age slide.

Cayrel: This is OK.

Guinan: Ah, if it's OK with her, it's OK [laughter].

Cayrel: But it is not OK with the masses!

Guinan: Well, we don't know masses. If you want the mass, you need to have it in an eclipsing binary system, which takes away any possibility of calling it a solar-like star.

Henry: I do have 18 Sco on the APT program, for just the last year, and it's absolutely quiet photometrically on the short term. So it has to be solar age.

Guinan: Yes, I have eight nights, and my variation is 0.003 millimags.

Ayres: This is a precaution regarding the issue of mass. The Sun, at one solar mass, is very close to the point in core evolution where the CNO cycle becomes important. So in the models for α Cen that Brian Flannery calculated, even at just 10% more than the mass of the Sun, there is a much more important role for the CNO cycle than in the Sun. That may very well have important implications for things such as the luminosity variations of the star, the oscillations, and so forth.

Guinan: A problem is that not many people study α Cen, because it's so bright. It's tough photometrically.

Ayres: But when one is talking about mass ranges for solar analogs, one should probably err on the low side. On the high side, maybe go up to 1.05, but really not much higher.

Guinan: Well, α Cen is one of the few systems where the mass is actually known, because of its membership in a binary system. So I like that star because it has a mass. For the other ones, you change the temperature by just 120 K or so, and the isochronal masses start to change a lot. They start slipping around on my diagram from 8 billion to 4 billion years! But I agree, α Cen is on the fringe of being useful as a solar twin. But as an analog, it's within my 10% criterion. It has a cycle similar to the Sun, 11 or 12 years, probably, that you can see in the IUE data.

Garrison: Just a comment from a classification point of view: 18 Sco is one of the closest, and so is α Cen and 16 Cyg A, but HD 1835 is way off.

Guinan: Yes, 1835 is out of the question, although some people still like it. I just think it's too young. And I didn't even get into the UV, but let me say that stars like this go way off in the area around 1500 to 2000 Å. They show characteristics similar to the active Sun, with enhanced UV continuum fluxes, which are probably plage-related. If you're using UV as a method for getting temperatures of stars, you can be badly misled. I mean, these stars are – are *on fire!* [Laughter.] They have light variations of 3 to 4% at least.

Radick: Well, that's enough 1835-bashing for now; it's time for lunch.