The Sun Among the Stars: How Reliable is our Picture?

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Abstract

It is widely believed that the observed 0.1% cyclic variation of the Sun's total irradiance arises from the presence of dark sunspots and bright magnetic faculae on the solar surface. While it has been known for decades that other lower main-sequence stars display behavior interpretable as magnetic activity, exploration of the technically challenging regime of stellar photometric variability at amplitudes approaching 0.1% has been slow and painstaking. Nevertheless, measurements now exist that permit a preliminary comparison of solar variability with its stellar analogs, a comparison that suggests the Sun's variability is fairly typical for a star of its age and mass. Among the numerous vexations encountered in reconciling the solar and stellar measurements, problems arising from comparison of star variability and inclination effects seem to be among the more important.

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Discussion following Richard Radick's talk

Skiff: Just from a practical standpoint, I think now that I've spent 12 years at the telescope, we can pick comp stars better than we could in 1984. Greg now has the advantage not only of having an APT capable of observing 150 stars a night, but also the advantage of our experience in picking comp stars.

Radick: How would you pick those comp stars? What would you do differently now than you did 12 years ago?

Skiff: Basically, I would avoid *everything* except mid-F stars, and get our Solar-Stellar Spectrograph folks to look at them first, to see if the R'_{HK} is elevated *at all.*

Radick: We found in our observations of Hyades stars that the variability turned off fairly abruptly as you got earlier than F7 or F8, and this is even for fairly young, active stars in the Hyades cluster. The problem then is that you've got a fairly large color difference between your comparison stars and some of your program stars. So you gain the security of a stable comp star, but you lose in the sense of having trickier color corrections.

White: Let me address the point you raised about the uncertainties in the Kitt Peak H&K measurements. Early in the program we had several observations per day. Within a given day, the repetition had a standard deviation of about a tenth of a percent. When I started comparing the values from day to day to day, where the Sun still had relatively the same activity between those days, the repetition jumped to 1%. Now, there are other measurements in there that can change from day to day, such as the measurement of the reference points at 3875, 4020, and 3950 relative to one another. So I think the range of variability is between 0.1 and 1 percent. How much I can narrow that, I don't know. But there's some indication, when you look at the solar minimum values between 1975, 1985, and 1996, it looks like we recover the minimum to within 2 or 3 percent for those three minimum periods.

Radick: The precision quoted from the Mount Wilson observations is also on the order of 1%, which makes me wonder, why is the Sun so smooth? I don't know – is it measurement error, something in the Mount Wilson observations that isn't understood, or is the Sun just very well-behaved?

Harvey: Is this one measurement per night shown here [in Mt. Wilson series for selected stars]?

Radick: Yes.

Guinan: One comment on your comp stars. You have to be very careful with early F, because of γ Doradus stars. I ran into *them.*

Skiff: Yes, at early F you still run into variable stars.

Radick: You want to be around F3 to F7, or maybe just F5 or 6.

Guinan: Another question: if you go into K-type stars on your program, won't you get more variability from flaring?

Lockwood: Everything falls apart in K. In one of the panels on my poster, we have a graph of the non-variability of stars as a function of $B-V$. There's a floor underneath all the points that is tilted. It's close to zero down around F0, and it goes up towards K, and by the time you get to the Sun's spectral type, it's about 0.3% rms. We suspect that it is undetected variability, but it also could be instrumental. We leave it as an exhibit to be evaluated by the reader.

Guinan: But with IUE, there is short-term variability in Mg h&k, probably due to flares, and I would guess that if you go to K you'll have more of a chance for this flaring.

Cayrel: HD 81809 was Mihalas's preferred star. He said that it has everything identical to the Sun. And afterwards, it turns out that it is a double star, and it was much more evolved than the Sun.

Lockwood: Any more questions for Rich? – OK, one more, one more long one.

Ayres: One long comment. I'd like to emphasize as strongly as I possibly can that there will be very little control over the errors, very little believability, unless you measure the Sun and the stars with the same instrument. And quite frankly, I think that's an extremely difficult proposition, because you're dealing with a 30-magnitude difference. You have strategies, of course, for coping with that, and I strongly encourage that type of approach.

Hall: A comment on that and the superstability of the Sun that Rich is showing here: we *are* observing the Sun and stars with the same spectrograph, by using a 1-meter telescope for the stars and a 200-micron telescope for the Sun, both of which see unresolved sources. For a candidate like 18 Sco, for which you [Radick] were mentioning these "ragged" observations from the Mt. Wilson database, we find over the past two years that its HK record is flat and very close to solar minimum. So chromospherically, it's just about identical to the Sun, and I suspect on the $B-V$ versus R'_{HK} plot it would practically overlie the solar symbol. But we've now started looking at the lines in our echelle spectra. The variability we see in those lines in stellar data sets, compared to identically-spaced solar data sets, seems to be greater in the stellar data, even for an excellent solar analog like 18 Sco, than in the Sun. It's like there's more "flicker" in the stellar photospheres than in the Sun. So this raggedness in Rich's plots for the stars, compared to the seeming superstability of the Sun, may well be real. I have to say these results are pretty tentative, since we just began this work. I need to go back through the whole exercise and be sure I get the same answer.