Who's the Customer?

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It's always nice to go last, because most of what you had to say has already been said [laughter], but even so it is perhaps good to say it again, or at least in a different way. I'm one of these non-experts as well, so presumably the following remarks are unbiased.

To me, the "twin" question, in the sense of finding a star, as near as we can measure identical to the Sun, in terms of certain properties, is a quite narrow thing. It's great sport, and it leads to a new champion every year, or every six months, apparently [laughter], and it has driven the study of early G stars in an important way. It should continue for that reason alone: to find out what is the range of properties of these stars, and to classify them, and to do it correctly.

It was pointed out that if you want to find lots of them, you need to go fainter. One of the criteria for finding a twin is that the luminosity should be the same, and that means we have to rely on parallaxes, and as we go fainter, obviously the parallaxes become more difficult. And already we have had some questions as to whether we should believe everything HIPPARCOS has told us. So that's an interesting set of concerns.

Now, broadening out from *twins* to *analogs*, that is, to stars similar enough to the Sun to be interesting for some reason, the question then becomes "Does one size fit all?" For example, I'd like to point out three different kinds of studies that rely on using solar analogs. Ed Guinan's work is focusing on the Sun as it evolves through time, from the young, highly active Sun to what it will be a few billion years in the future. For that, obviously what counts is *not* finding an exact solar twin! Perhaps we just want a solar-mass star with similar composition.

Then there's Brian Skiff's work in support of Lowell's planetary research program, which includes finding Suns that can be observed at night. One can then subtract the spectrum of sunlight from that of a comet's tail, say, in order to study emission bands. Marc Buie is sitting in the back wondering how he can study reflectance spectra of solar system objects, and isolate what the object is contributing rather than what the Sun is contributing. This is a very different use of a solar analog than what Ed Guinan is after.

And then, Derek is after things that have similar dynamos to the Sun. That doesn't mean they have to be identical to the Sun in every way. They just have to have some scaled properties, some kind of dynamo numbers, for example, that are similar to the Sun. Or, if you want to test a dynamo theory by looking at different sets of dynamo numbers, then you want solar analogs but you also want objects "on either side" of that.

So, "who is the customer" is the question. Is it a plasma theorist, interested in what's going on in the upper atmosphere of the Sun, with questions about solar activity? In this case, concerns about the range of solar properties become important. Is it a cometary spectroscopist, who simply wants to get rid of the sunlight? Is it a dynamo theorist? Is it someone interested in solar-stellar connections, or the aging of the Sun? Is it an asteroseismologist, who wants to find systems like the Sun that will vibrate in similar ways? Is it someone interested in issues of stellar structure and evolution, who doesn't want a perfect twin, but wants to compare the Sun with objects of slightly different mass, metallicity, rotation, and so forth, to see whether our understanding of the theoretical structure of the Sun is robust?

All of these are different customers, with different requirements for solar analogs. So, must a solar analog be one solar mass within some relative error? If you're Ed Guinan, the answer is probably yes. Must the analog be 4.5 billion years old? If you're Ed Guinan, the answer is no! Must it have a surface temperature very close to the Sun? Must it be a slow rotator? Must it have no close companions? That has been asserted at this workshop a number of times, mostly in the context of how hard it is to measure the mass of something *without* a companion. But that's tricky, for if the circumstances of birth profoundly influence the future evolution of the object, you are locking out an important line of study by demanding that solar analogs not have companions. Must solar analogs have planets? What does that have to do with the solar rotation, given the angular momentum budget of the solar system? Must solar analogs have Maunder-type minima? — in which case we're in *big* trouble, because we'll have to look at them for hundreds of years before we decide what is a good analog!

So, we're about to go into these sessions to sort out what is the best analog of those available, or what parameters we should put emphasis on. I think we can do that, in perhaps a friendly way, but I'm not sure that "one size fits all," and so there may be some significant reservations or minority opinions along the way.