M Dwarfs: The Search For Life Is On

August 30 2005

When you look up at the night sky, none of the stars you see are M dwarfs. These diminutive stars, much smaller and dimmer than our own sun aren't bright enough to see with the naked eye. Yet M dwarfs (also known as red dwarfs) are by far the most common stars around, comprising some 70 percent of all the stars in our galaxy.

Historically, scientists interested in the search for extrasolar life have shied away from studying M dwarfs. Because they put out much relatively paltry amounts of light and heat, compared to the sun, the general feeling among scientists was that they were unlikely to host habitable planets.

But at a recent Workshop on the Habitability of Planets Orbiting M Stars, sponsored by the SETI Institute in Mountain View, California, a group of astronomers and biologists got together to reconsider the question.

The impetus: The SETI Institute is building a massive radio telescope array to search for radio signals from extraterrestrial civilizations; they want to know whether to include M dwarfs in their list of search targets.

Astrobiology Magazine's managing editor Henry Bortman caught up with Todd Henry, one of the workshop's participants, at the conclusion of the workshop. Henry is a professor of astronomy at Georgia State University, in Atlanta, Georgia. His research focuses on detecting and cataloging all of the stars within 25 parsecs [about 82 light years] of the sun. He is particularly interested in M dwarfs.

Astrobiology Magazine (AM): You've just sat through a two-and-a-half-day workshop on the habitability of planets orbiting M-dwarf stars. What came out of this meeting?

Todd Henry (TH): I think we saw a paradigm shift. There has been a little momentum building in the last few years that M dwarfs are not so inhospitable for life on a planet going around them. But this is the first major shift that I've seen. I came to this meeting still with a question mark - although M dwarfs are my favorite kinds of star, and I think we should be looking at them. The question mark for me was, Do other people really believe this, or is it just sort of talk?

And what are the real problems? And I expected in two-and-a-half days to have a couple real dragons raise their ugly heads and say, This is a major problem; it really isn't going to work. And none of them appeared. Now, I think we have a fairly optimistic group, because the people who were here would not have come if they didn't think M-dwarfs were worth at least looking at. But I really expected something to pop up, and nothing did.

AM: Maybe I should back up and ask: What is an M dwarf?

TH: An M dwarf is the smallest kind of star there is. They have masses ranging from about 50 percent of the Sun's mass down to about 8 percent of the Sun's mass. That's a huge range, as far as stars are concerned. Because, for example, the amount of light coming to our eyes, if we were on a planet going around an M dwarf, would vary from one end of the range to the other by a factor of about 10 thousand. So you have a lot of different environments around M dwarfs.

AM: And the Sun is a G type star?

TH: Right. The sun is a G dwarf. G stars account for about 5 percent of all the stars in the Universe. And M dwarfs are at least 70 percent.

AM: So when you look up at the sky at night, most of the stars you see are M dwarfs?

TH: No. There's not a single M dwarf you can see when you look at the sky. They're so faint compared to the stars you do see at night, that even with binoculars, you have to know exactly where to look to see one. So astronomers have sort of struggled studying those. And they tend to get ignored because they're harder to study.

AM: How many M dwarfs are known now?

TH: Within 33 light years, which is 10 parsecs, there are 240 known M dwarfs. There are definitely more. Stars with a spectral type of G, like our sun, there are only 21. So you've already got a factor of about 12 more of the little red guys than we do of the yellow ones.

AM: Historically, most scientists thought M dwarfs were unlikely candidates as host stars for habitable worlds. Why?

TH: The problem for the M dwarfs is that their habitable zones are very narrow. You would have to put a planet right in that narrow habitable zone for it to have liquid water on its surface. But if you integrate the total amount of habitable zone around M dwarfs versus G dwarfs, you get about the same amount. Because there are so many more M dwarfs.

AM: So your odds of finding a planet in the habitable zone around any specific M dwarf are slim, but the total amount of habitable zone around all M dwarfs combined is equal to the total amount around sun-like stars.

TH: Right. And the bonus is that the M dwarfs, on average - if you had to look at 100 M dwarfs or 100 G dwarfs - are so much closer. So my bet is that we're going to find life on something going around an M dwarf before we find it around a G dwarf.

AM: What have been some of the other arguments against the habitability of M dwarfs?

TH: The big argument has always been that to put a planet in the so-called habitable zone [of an M dwarf], you have to move it in so close to the star - because the star is so much cooler and has less radiation - that it locks, just like the moon tidally locks to the Earth.

And so you have the same face of the planet facing the star all the time. And if you do that, it has been said, that you'd be boiling away any atmosphere or ocean on the side facing the star and it would be trapped on the dark side and would freeze out.

It turns out that's probably not right. The locking would occur. But it doesn't take that much atmosphere to redistribute the heat. So if you have a little bit more than the Earth's atmosphere - I think that is what's required, but it depends on what molecules are in the atmosphere - you can actually stir the atmosphere up enough and move the heat around the planet. So it doesn't matter if it's tidally locked or not.

You still have a good temperature on the whole surface. Some of it's faced toward the star, some of it's facing away from the star, and it doesn't seem to matter. That was the biggest hurdle to get over.

Then there were all kinds of details that go along with that. Not all planets would be tidally locked. There could be another planet in the system that forces it to be in some sort of resonance that would keep it spinning. You could have a slightly eccentric orbit that makes it wobble and librate like the moon does, back and forth. So the details can get you out of a lot of problems.

AM: You said that having an atmosphere a little thicker than Earth's could overcome the tidal-locking problem. But wouldn't being closer to the star mean that stellar radiation would be more likely to blow out the atmosphere completely?

TH: That is one of the big problems we came up with. I think that is the largest dragon-head that we saw, that you can sputter away the whole atmosphere - in about a billion years, was the back-of-the-envelope calculation. That really needs to be cleared up. That may be the biggest danger.

But you can get away from that as well. If you have a lot of radiation hitting a planetary surface and there's liquid on it, you're going to be creating atmosphere really quickly, as well. So you may sputter a lot away, but you might just keep regenerating it, so it's not a problem.

AM: Anything else?

TH: The other big gotcha was the intensity of the solar flares - we've sort of known about this for a while - whether you get X-rays and ultraviolet problems. When you're an organism sitting on a planet's surface, you really care about several things coming at you.

One is X-rays, because they can damage any molecular structure that gets established. One is ultraviolet, for the same sort of reason, at slightly lower energies. One is particles that are coming from the star itself. And you might also worry about whether or not the spots on the stars change the overall flux of the radiation, whether you get enough visible or infrared radiation.

Each of those four things could have been a major problem. But we pretty much decided that there were always ways around them. The best argument against the UV rays and the X-rays in particular is that an M dwarf emits most of that in the first billion years of its life. And once you're through that, then it gets pretty nice.

So all the bad stuff happens early. So you just wait. You just wait for your habitable zone to stabilize and your star to stabilize. And then you've got billions of years to play around with the chemistry on the surface.

AM: So, your general conclusion is…?

TH: M dwarfs are great. M dwarfs are definitely good. M dwarfs are back on the table.