Hi this is Steve Nerlich from Cheap Astronomy www.cheapastro.com and this is *Forbidden planets.*

So we all know this story. Uncle Owen has just emotionally blackmailed you into putting off your application to the academy for another year - and that's even after you just got those two new droids, darn it. So you find yourself staring mournfully at the setting binary suns and… hmm.

Given that both of those Tatooine suns have apparent angular diameters similar to how the Sun looks in our sky, it's kind of implied that the planet is roughly one astronomical unit from each of those stars, that is about the distance from the Earth to the Sun.

I mean both are too bright and too white to be red dwarfs and if they were main sequence giant stars, even at a much greater distance than one astronomical unit they would probably still manage to deliver lethal doses of high energy radiation onto the planet – and probably generate enough solar wind to blow away the atmosphere – and they would only last of few million years before going supernova, which would be insufficient time for the indigenous Tatooine life-forms to have evolved.

So let's run with the idea that Tatooine really does have two stars of approximately one solar mass each at a distance of about one astronomical unit.

It is generally assumed that 50% of all stars in the universe are in binary and other multiple systems, although this statistic arises because these systems have two or more stars each. It is still the case that the most common star system is a single star system, although most of these stars are smaller M class red dwarfs – which are the most common star type overall. In fact it's estimated that 85% of all stars in the universe are red dwarfs - and only 25% of these red dwarfs are in multiple star systems. So, it is mostly stars of one or more solar masses that are found in binary and other multiple star systems.

Binary stars can orbit each other either closely or at quite a distance - and most often they are stars of quite different sizes. The closer together they are the faster they have to move to remain in a stable orbit about their common centre of mass, but that's not a problem in itself. Indeed, all sorts of binary star variations are possible and observable – including examples of similar-sized binary stars that are as close, or even closer to each other than one astronomical unit.

Where it gets interesting then, is trying to determine how planets might form around these binary systems. Despite the forbidding title of this podcast, it is certainly possible to have planets in binary star systems – and we have already observed several examples from the 400+ catalogue of exoplanets we have today.

These planets can be circumbinary, where their orbit actually encompasses both stars – or they can be circumstellar, orbiting just one of the two stars. The general rule is that close binaries will only support circumbinary planets and distant ones will only support circumstellar planets.

At least mathematically, it’s traditionally thought that a circumstellar planet in a binary system can only maintain a stable orbit around one of the stars at a distance from the star that is less than about one seventh of the distance between the two binary stars at their closest approach.

So, for example, the solar system could support a second Sun at the distance of Saturn’s orbit – which is about 9.5 astronomical units out – but you couldn’t have a second Sun at the distance of Jupiter, as being only five astronomical units from the Sun – it would disrupt the Earth’s orbit

Nonetheless, even with the scenario of a second Sun at Saturn – from Earth, that second Sun would be appear to be about a tenth of the size of our real Sun and a hundred times dimmer by an inverse square relation – so it’s not looking like Tatooine can be a circumstellar planet.

The rules for permissible circumbinary planets are more difficult to elaborate. From a great distance two binary stars become gravitationally indistinguishable from one star, so a planet could maintain a stable orbit around both stars if it was at a great distance. Alternatively, if two binary stars are very close to each other then again they become gravitationally indistinguishable from one star – so, a planet could orbit closer to them.

Where planets are forbidden is in that range where the planet is not far enough out that the gravitational differentiation of the two stars becomes irrelevant. In this forbidden zone, the planet would be exposed to gravitational pulses as one star passes and then the other passes – which would make a stable orbit almost impossible.

It’s thought that if you want a planet in a one astronomical unit orbit around approximately solar mass binary stars – you would need to squash those stars in an orbit of around one tenth of an astronomical unit - or otherwise you need to position your planet way out past the habitable zone - where water can exist as a fluid.

But even then, having Tatooine at one astronomical unit out from its binary suns still creates a few problems. Having two solar mass stars in the sky at one astronomical unit distance, would mean the planet receives roughly double the solar flux that Earth does. I mean OK, Tatooine is a desert planet – but receiving double the Earth’s solar flux would make it more like Venus - which does actually receive approximately twice the solar flux that the Earth does - even though it's only 28% closer to the Sun, due to that pesky inverse square relation again.

So, maybe the planet has to be a bit further out than one astronomical unit - meaning it's now stretching belief that those stars could appear to be as large as they do in Tatooine’s sky. To make their diameter bigger you have to start adding proportionately more mass - which will quickly push them into a more intense spectral class. For example, the star Sirius A has 1.7 times the diameter of our Sun because it has about 2.5 times the mass of our Sun - which puts it into spectral class A - which means it's pumping out about 25 times the brightness and the stellar flux and the stellar wind that our Sun does.

So I guess the key message to film makers is that if you want an Earth analogue orbiting two binary Sun analogues, those Sun analogues need to look significantly smaller in the sky than the real Sun would.

Otherwise, the most unusual about the Tatooine arrangement is that both stars appear to be almost identical. Binary systems more often have a big primary star and a smaller companion - or companions, since triple or even more multiple star systems are certainly out there.

So in the end, what all this means is that the universe still demonstrates the rule that truth is nearly always stranger than fiction and it also shows that even Tatooine could work if its stars just looked a bit smaller in the sky than they do in the movie.

Thanks for listening. This is Steve Nerlich from Cheap Astronomy, www.cheapastro.com. Cheap Astronomy offers an educational website where Earth isn't necessarily the standard model - and might even be a little bit exceptional - but hey what's wrong with that? No ads, no profit, just good science. Bye.