The Rorschach World

by Colin Johnston, Science Communicator

If you went outside at about 11.30 pm in the middle of June in 2007 and look towards the South you would have seen some interesting things in the sky. Lying almost due South was the giant planet Jupiter, a brilliant sight. Just below and to the right of it was reddish Antares. Almost directly in the South-West at this time of year will be the bright and bluish Spica. Between these stars lies the faint constellation of Libra, looking more like a flowerpot than a set of scales. If your observing conditions are good, try finding Beta Librae (also called Zubenelschamili) the brightest star in the constellation. If you can see Beta Librae you are looking towards another star, the M-class red dwarf Gliese 581, which suddenly became very famous in April 2007. Sadly you won't be able to see it, it is just too faint. So why did Gliese 581, a dim and obscure star, gain so much attention?

The media reported that this star has a 'habitable' planet. The planet may receive just enough heat from its sun so that it is neither too warm nor too cold for liquid water to exist there. All the other exoplanets (extra-solar planets) discovered so far are either too hot (because they are too close to their stars) or too cold (because they orbit too far out) for water to remain a liquid, which is essential for the existence of life as we know it. Artists' impressions of its surface depicted landscapes with dark oceans, jagged spires of rock and the neighbouring Gliesian planets looming in crimson skies. Just possibly, life could have arisen there. Perhaps we have neighbours just 20.4 light years (6.3 parsecs) from us. Should we send them a friendly greeting or prepare for visitors here on Earth? Or is this planet just science fiction?

Research carried out by a team led by Stéphane Udry of the Geneva Observatory, suggests that there are three planets orbiting Gliese 581. We cannot see the planets directly; it will be decades before we have telescopes which can make images of such faint and tiny objects. Instead we infer their existence from observable 'wobbles' in the star. Presumably the gravitational pulls from orbiting worlds are enough to tug the star out of position. The Gliese 581 system is very different from our Solar System. The innermost planet, Gliese 581b, is as big as Neptune. Meanwhile, the outermost planet, Gliese 581d, is eight times as big as the Earth and orbits closer to its star than Mercury does to the Sun. This is fascinating, but it is the planet between them that grabbed the public's attention. This is Gliese 581c.

There are no protocols for naming exoplanets, so Gliese 581c is all the designation the planet may ever have. Unfortunately it is a clumsy, unfriendly name, so for the rest of this article I am going to refer to Gliese 581c as 'Rorschach'. Please do not think I am trying to name it, this is just to make this article easier to read. Why this name? Well, you will see why it is appropriate by the end of the article.

> "Just possibly, life could have arisen on Gliese 581c"

Like all red dwarf stars, Gliese 581 is much smaller and cooler than the Sun. It is only about a third the size of our star and about 3000° C cooler. As a result it is much dimmer (only 1% as bright as the Sun). The lower temperature means that it is redder that the Sun. Beings native to Rorschach would have eyes adapted to this so they would see yellow, orange, red and infra-red light, but blue and violet would be as invisible to them as ultra-violet is to us.

If the observations by Udry and colleagues are correct, Gliese 581 is accompanied by a planet five times as massive as Earth and about 1.5 times as wide. This is Rorschach, Gliese 581c. The planet orbits 0.073 AU from the star

Image Credit: ESO

Gliese 581c Although we can see the red dwarf, this fanciful artist's impression suggests a second, whiter star is also illuminating the planet.

(1AU=150 million km, the earth orbits 1AU from the Sun). Assuming these statistics are correct we can begin to make predictions about its environment. For example, its surface gravity is 2.2 times that on Earth's surface, so a 70 kg person standing on Rorschach would weigh 155 kg. We know how bright the star is so we can calculate how much solar energy the planet receives. We have seen how Gliese 581 is very small and dim compared to the Sun, but Rorschach is much closer to it than Earth is to the Sun. If you stood on the surface of Rorschach and could see Gliese 581 it would appear as a distinctly reddish glowing disc five times as wide as the Sun appears from Earth. This proximity means that in fact, the planet receives more than twice as much solar energy per square metre than the Earth.

Straight away, here is an enormous difference between our planet and the new discovery. If the Earth suddenly started to receive as much heat from the Sun as Rorschach does from its star it would be a disaster. Trapped by the greenhouse effect, the heat would soon bake the life from the Earth's surface. This does not necessarily mean the same thing has happened on Rorschach; perhaps it is covered pole to pole with a layer of reflective clouds at the top of its atmosphere. Solar radiation would bounce off this curtailing a runaway greenhouse effect there.

It is very likely that Rorschach is tidally locked to its star. The powerful torque applied by the very close star's gravity over the aeons will have forced Rorschach to take as long to rotate around its own axis as it does to revolve around its sun. A year on Rorschach lasts 13 of Earth's days and almost certainly a day on Rorschach lasts equally long, so the planet will not rotate with respect to its star. One side always faces the star in eternal daytime sunshine, the other side always faces the dark in eternal night. This immediately means Rorschach is again very different from Earth. If you are on the dayside of Rorschach, the sun will never set, hanging ominously in the sky. This may seem odd but tolerable, however imagine what could happen to a planet with an atmosphere and oceans which suddenly started to rotate like this. The dayside would warm up, with no cool of night, temperatures would soon become intolerable. Meanwhile the darkside cools, and the oceans become icebound. Wind circulation will act to distribute the heat, but on the darkside the gases in the atmosphere begin to liquefy, then freeze. In the icy darkness, the atmospheric pressure drops, sucking more and more air from the dayside. Soon the surface on the darkside is an icy, airless wasteland, probably resembling the surface of Ganymede or Callisto. In contrast, the dayside is a hot, almost airless desert, like Mars baked in an oven. To avoid this fate, Rorschach must have a relatively thick atmosphere to 'even out' the temperature, but not so dense as to lead to a runaway greenhouse.

Discovering a comparatively tiny world around another star is an amazing achievement, but we cannot pin down any other significant facts. All the information we have about Rorschach can be listed in a couple of sentences. We know its size, mass and distance from its star. As to what the

Image Credit: Karen Wehrstein via Daily Kos

Gliese 581c Seascape Artist Karen Wehrstein's impression of a scene on the planet is more accurate than most. Note that this is not a sunset; the star is fixed in this position in the sky.

planet is really like, we can only speculate. Here are just a few possibilities as to what Rorschach could be, all are equally likely based on the limited information we have at present:

•A huge airless ball of barren rock, a sort of super-Mercury

•A giant version of Venus, rendered hellish by the combination of abundant solar heat and a greenhouse effect

•An almost airless desert on one side, a dark, frozen steppe on the other

•A world where the continuous cloud cover means the dayside enjoys a temperate climate with oceans of water and conditions suitable for terrestrial life.

•A world covered with oceans almost at boiling point with a steamy atmosphere of carbon dioxide

•A warm 'mini-Neptune' with a hydrogen and helium atmosphere swamping a huge rocky core

Psychologists used to show their patients cards featuring coloured blobs and asked them to describe the picture they could see. This was the celebrated Rorschach Test and was designed to give the psychologist insights into the patient's personality. Gliese 581c is a kind of cosmic Rorschach test. Look at the data; what kind of world do you see?