Living Near a White dwarf

By Avi Loeb on September 29, 2020

Recently, the first planet to orbit a white dwarf - named WD 1856+534, was discovered through its transit every 1.4 days. Remarkably, this giant planet, WD 1856b, is seven times bigger than the stellar remnant it transits. Most likely, there are rocky, Earth-size planets at similar distances from other white dwarfs - in which case they would possess a surface temperature similar to that of Earth. This hits us close to home.

In about a billion years, the Sun will brighten up enough to boil away the oceans on Earth through a runway greenhouse effect. In order to survive, our civilization will have to migrate outwards in the Solar system. Seven billion years later, the core of the Sun will shrink to its remnant, a white dwarf, carrying about half of the Solar mass with the rest lost.

A white dwarf is a hot, dense, metallic crystal ball, roughly the size of the Earth - 1.4 Earth radii in the case of WD 1856+534, cooling off with no central nuclear engine. There are ten billion white dwarfs in the Milky Way galaxy because some Sun-like stars had already ended their life. This is a result of a fortuitous coincidence between the life span of Sun-like stars and the current age of the Universe.

After a few billion years, a white dwarf cools to a surface temperature similar to that of the present-day Sun. In particular, WD 1856+534 was estimated to have an age of 6 billion years and a surface temperature of 4700 degrees K, somewhat lower than the current Solar value of 5800 degrees K. The newly discovered planet is 50 times closer to WD 1856+534 than the Earth's distance from the Sun. Since this white dwarf is 76 times smaller in size than the Sun, an observer located just inside the orbit of the detected planet, at about a percent of the Earth-Sun separation, would witness an illumination similar to that on Earth, with WD 1856+534 occupying roughly the same angle as the Sun does on our sky. In such a "habitable zone" around any white dwarf, Eric Agol suggested in a 2011 paper that liquid water may exist on the surface of a rocky planet, enabling the chemistry of life as we know it. Owing to the short orbital time, residents of a habitable planet around WD 1856+534 would be busy celebrating their birthday every day, the equivalent of an Earth's year around the Sun.

Given that the luminous surface area of a white dwarf is ten thousand times smaller than that of the Sun, absorption features from a planet's atmosphere during a transit of a white dwarf are much more easily detectable than for Sun-like stars. During a full transit which lasts a few minutes, an Earth-size planet would occult the entire white dwarf. Given the proximity of the planet to the star, the transit repetition rate is hundreds of times larger compared to the habitable zone of a Sun-like star. As argued in my 2013 paper with Dan Maoz, these circumstances offer the best opportunity for detecting biosignatures in the atmospheres of exoplanets, in the spirit of the phosphine detection in the cloud deck of our

neighboring planet, Venus. Our calculations were refined in a recent paper by Lisa Kaltenegger and collaborators. If the planet hosts a technological civilization, one could also search for signs of industrial pollution in its atmosphere, as demonstrated in my follow-up study with Henry Lin and Gonzalo Gonzalez-Abad in 2014.

A close-in habitable planet will be tidally locked - showing the same face to the white dwarf, with permanent dayside and nightside. As it turns out, the habitability distance is dangerously close to the innermost region where the planet would be destroyed by the gravitational tidal force from the white dwarf. Since the habitable zone is not very far from the tidal disruption distance, tides could raise a substantial bulge in any ocean or atmosphere on the planet's surface.

What are the consequences for our long-term future? As the Sun will turn into a white dwarf, our descendants could aim to populate the habitable zone near its remnant. For Astronomy, a tidally-locked planet would offer the benefit of a permanent nightside where telescopes can be placed to observe their dark sky nonstop. For the economy, the white dwarf surface would offer the efficiency of nuclear reactors but of clean energy. By damping trash onto the surface of the white dwarf, one could harvest its gravitational binding energy from the emitted radiation at nearly the yield of nuclear fuel.

Given this perspective, there might already be analogs of our civilization that recognized the benefits of living around white dwarfs. We could find them by searching for the spectral signatures of the trash they damp on the white dwarf surface, or by searching for the Chlorofluorocarbons (CFCs) pollution of their planet's atmosphere from their air-conditioners. Among all industrial civilizations, it would be easiest to detect the environmental impact of mildly-intelligent ones, those who are not friendly to their habitat. The only problem is that they might be short lived and consequently less abundant.

ABOUT THE AUTHOR

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(Credit: Nick Higgins)