Habitable Zones in Extrasolar Planetary Systems: the Search for a Second Earth

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Abstract

Is there life beyond planet Earth? This is one of the grand enigmas which humankind tries to solve through scientific research. Recent progress in astronomical measurement techniques has confirmed the existence of a multitude of extra-solar planets. On the other hand,enormous efforts are being made to assess the possibility of life on Mars. All these activities have stimulated several investigations about the habitability of cosmic bodies. The habitable zone (HZ) around a given central star is defined as the region within which an Earth like planet might enjoy the moderate surface temperatures required for advanced life forms. At present, there are several models determining the HZ. One class of models utilises climate constraints for the existence of liquid water on a planetary surface. Another approach is based on an integrated Earth system analysis that relates the boundaries of the HZ to the limits of photosynthetic processes. Within the latter approach, the evolution of the HZ for our solar system over geological time scales is calculated straightforwardly, and a convenient filter can be constructed that picks the candidates for photosynthesis-based life from all the extra-solar planets discovered by novel observational methods. These results can then be used to determine the average number of planets per planetary system that are within the HZ. With the help of a segment of the Drake equation, the number of "Gaias" (i.e. extra-solar terrestrial planets with a globally acting biosphere) is estimated. This leads to the thoroughly educated guess that there should exist half a million Gaias in the Milky Way.