How common are Earth-Moon planetary systems?

Our Moon formed via a giant impact between our young Earth and a Mars sized proto-planet over four billion years ago. The material torn from the Earth's surface during the collision accumulated in orbit and formed our familiar satellite. After its formation the Moon was ten times closer to the Earth than it is today and it has drifted slowly away to its present position. Its early intense gravitationally attraction would have caused tidal waves to pass across the Earth's surface several times per day which may have influenced the initial development of life. In addition, without its satellite, the Earth would suffer chaotic variations of the direction of its spin axis which result in large fluctuations of its surface temperature. Our Moon stabilises the direction of the Earth's spin and has thus guaranteed a stable climate over its entire evolutionary history yielding a suitable environment for life to evolve on its surface.

If life were to develop elsewhere in our Galaxy, on planets orbiting other stars, it is interesting to determine not only the frequency at which rocky planets like the Earth form, but also the chances that such planets host their own massive stabilising moons. Is our Earth special and life in our Galaxy apparently rare because of the small chances of such a giant impact occurring to form a large moon? To answer this question we completed a large set of supercomputer simulations that follow the formation of planets via the collisions that occur between thousands of small rocky bodies that orbit a central star. We determined that most stars like our Sun should have an Earth-like planet orbiting within its habitable zone, the distance from the star where water would stay in a liquid form. We then identified the late time giant impacts that would lead to the formation of a gravitationally bound satellite and could determine how long it would be able to stabilise the spin axis of its host planet. Many satellites are too small and drift away from their planets too quickly, but we find that Earth-Moon like planetary systems do occur with more than 1 in 12 terrestrial planets hosting a massive moon. Uncertainties in our study result in a range of 1 in 4 to 1 in 45.

Figure: This evolutionary "merger tree" illustrates the collision history between the initially small rocky bodies that result in the formation of a single planet-satellite system from one of our simulations. The root of the tree is the final planet and the branches show the numerous collisions that take place early on. The width of the lines give the size of the forming planet and every knee in the tree illustrates when a merger occurs between two objects. The red branch shows the history of the giant impactor that leads to the formation of the planets moon.

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http://xxx.soton.ac.uk/abs/1105.4616

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