**The Planet Factory: exoplanets and the search for a second Earth**

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The search for a second Earth has become a new favourite theme of popular media, encouraged to a significant extent by many of the scientists involved in the research. In the opening lines of the Introduction, *The Blind Planet Hunters,* Elizabeth Tasker recalls the classical tale of the blind men trying to define an elephant by touching only parts of the beast, which she directly compares to the current state of knowledge of the diversity of planets and planetary systems.

Tasker is an astrophysicist and associate professor at the Japan Aerospace Exploration Agency. Not only does she she have a thorough grasp of the subject, she has a delightful, lucid way with words that allows her to successfully communicate an inherently complex message to any interested reader, no matter what their level of science literacy. Her writing style could be described as "astrophysics and planetary science meet Sherlock Holmes". Rather than providing encyclopedic reams of data, she offers an easily understood narrative throughout the text that describes the questions, observations and hypotheses planetary scientists have been and are currently working with. Her intent is to arm the reader with an understanding of the principal mechanisms and processes involved in making planets, highlighting the interplay between the different variables involved, which she explains in elegantly simple terms, commonly drawing on everyday analogies. Then, rather like a mystery whodunnit, for each of the many case studies she presents, she reveals new clues that led planetary science to modifiy the hypothesis of the moment. The interested reader quickly realises that this is going to be a throughly engaging roller-coaster ride, and will have trouble putting the book down.

The Introduction clearly explains the science behind the two principle techniques for detecting planets beyond our own Solar System (exoplanets): systematic star wobbles and brightness variations. Tasker then presents planetary science in three parts. Part 1, *The Factory Floor*, takes us from the planet-forming protoplanetary disc to the rapid (10 million years is fast !) formation of planets. She readily explains the limitations of our knowledge of exactly how this occurs, even in our own Solar System. There's a lot to be considered here: (i) building solid planets by accretion from protoplanetary dust involves interplay between solid particles and gas; (ii) building gas giants - especially their atmospheres - involves interactions between competing gravitational influences, gas temperature, and the role of accretion *vs* disk instabilities; (iii) building planetary systems involves an understanding of where planets originate within protoplanetary discs, and how planets migrate inwards and outwards, depending on the presence or absence of gas in the disc. It is a testament to Tasker's skill as a teacher that she manages to convey all of this apparent complexity to the lay reader with truly competent ease.

Part 2, *Dangerous Planets*, presents the spectrum of planet formation theories by applying the theoretical aspects, well explained in Part 1, to a range of case studies. She deftly handles the (Kozai-Lidov) interactions that can occur between orbital ellipticity and inclination via the gravitational interplay between multiple bodies (e.g two stars and a planet) that can lead to all sorts of observed planetary system configurations. Starting with the discovery of "hot Jupiter" exoplanets, that must have migrated in toward their central stars, Tasker reviews the determining factors controling planet migration, with easily understood explanations of the popular Grand Tack and Nice models. The migration of "hot Jupiters" may be instrumental in the formation of super-Earths and mini-Neptunes, the commonest types of exoplanets observed to date, but it's not that simple: what happened when no "hot Jupiters" are present. This is where Tasker presents her first detailed case study: the planetary system orbiting the star Kepler 11. The purported presence of at least 5 super-Earths but no "hot Jupiter" obliged planetary scientists to look to stellar magnetic fields to explain their observations - until, that is, they realised that all 5 planets were in fact mini-Neptunes ... at which point the problem switched to how to stop the gaseous planets from growing to Jupiter-size and larger. The many other case studies presented follow a similar, easy to follow now-you-see-it-now -you-don't pattern, as in the case of 55 Cancri b, by turn hypothesised to sport a surface ocean, a mantle made of diamonds, a crust made of silicon carbide - although it may be made of molten silicate lava - and a toxic carbon monoxide atmosphere. If that's not enough excitement, the planet's surface temperature may fluctuate between 1000-2700°C, and its size appears to oscillate dramatically over a short time frame. In other case studies, Tasker explains the many disagreable effects of tidally locking a planet to present the same face to its central star: you would not want to live there!

After rounding off Part 2 with an examination of planets associated with binary star systems and rogue planets with no associated star at all, Tasker turns to examining planets from the perspective of potential life in Part 3, beginning with a detailed examination of the misnamed "habitable" (Tasker prefers *temperate*) zone. In her accessible narrative style, she presents the *Goldilocks Criteria*, variables that influence and control the development of a pleasant, inhabitable planet for life as we know it. She explains how greenhouse gases work and why the Earth is located between the *Maximum Greenh*ouse and the *Runaway Greenhouse* limits within our Solar System, the *faint young Sun paradox*, and the roles of gravity and magnetic fields in retaining or losing planetary atmospheres. Using the case study of the planetary system around the red dwarf star Gliese 581, that included what the discovery paper described as the "most Earth-like of all known exoplanets" Tasker weaves a cautionary tale of runaway greenhouse environments, primitive atmospheres with no water, tidal locking with major temperature differences on the day and night sides, and the "disappearance" of purported planets that simply weren't there in the first place! Part 3 concludes with, among other fascinating topics, the consequences for habitability of water worlds, frozen moons, and atmospheric collapse on tidally locked "eyeball" planets, and ends with a brief examination of the difficulties inherent in detecting life on exoplanets at a distance.

If you read the book this far, you will truly understand its central theme: it's not enough for a planet to be located in its star's "habitable" zone for it to be a second Earth. Personally, I found this book to be both fascinating and enlightening. It is ideally suited to any amateur astronomer interested in planetary science. I strongly recommend it, and at CAN$32.00, the price is right.

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