

# Field Manual of Fine-Tuning

## Chapter Notes: Habitability

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*Date of Interviews:* 15-16 June 2016

*Date Deliverable:* ?? Mar 2016

*Audio Recorded?* No

*Video Recorded?* No

*Workshop Attendance:* TBA

### **Physics Covered**

fine-tuning in astrophysical environments and cosmological time.

### **Previous Chapter:**

Unknown.

### **Following Chapter:**

Unknown, likely Schrödinger equation and life

### **Types of Fine-Tuning:**

Likelihood of life at a given time and a given place.

### **Directly explored Fine-Tuned Parameters:**

- $P_{life}(now)$ : probability of life at present time
- $m_*$ : mass of life-harboring stars

### **Indirectly explored Fine-Tuned Parameters:**

- x

### **Assumed Background:**

- basic astrophysics
- basic cosmology

**Outline of Chapter:**

## Introduction

- What is fine-tuning in the context of habitability?
- What are the goldilock parameters (e.g.  $B_{Earth}$ ,  $B_{Sun}$ ,  $D_{GC}$ ,  $T$ , cosmic ray flux)
- When could life have started

Habitable Zones: Solar Systems (*leave this to the solar system chapter*)

- Earth's position in the Solar System
- Role of solar winds
- Earth's magnetic field
- Importance of greenhouse effect and planetary atmospheres
- The Moon as a shield against impacts
- Gravitational shield of Jupiter
- Why does Jupiter shield the goldilock zone instead of enhancing the probability of impact?
- Role of the asteroid belt
- Why do we find ourselves orbiting such a small Sun
- Ice line close to the asteroid belt and cometary impacts
- Frequency of impact of comets: why is it so low
- Is there something special in our distance to the Sun; we need temperature gradients which is higher for smaller stars.

## Habitable Zones: Galactic

- Are we a typical solar system in the galaxy
- Why are we here if there are way more stars close to the centre of the galaxy
- Cosmic ray flux is not too high that would kill us nor too low such that there would be no mutations and evolution
- Role of cosmic rays
- Does the galactic magnetic field play a role?

## Habitable Epochs

- Early universe had enough temperature for liquid water, but there was no water (first SNe haven't yet happened); is there a relation between expansion time scale (cooling the universe) and time of formation of first stars?
- Coincidence problem.
- First supernovae epoch needed for generation of higher mass elements.
- Stellar evolution within the galactic evolution.

## Others

- Anthropic constraints (goldilock zones).
- Life in the early universe and argument against the anthropic derivation of  $\Omega_\Lambda$ .