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Habitable exoplanets statistics in the Milky Way

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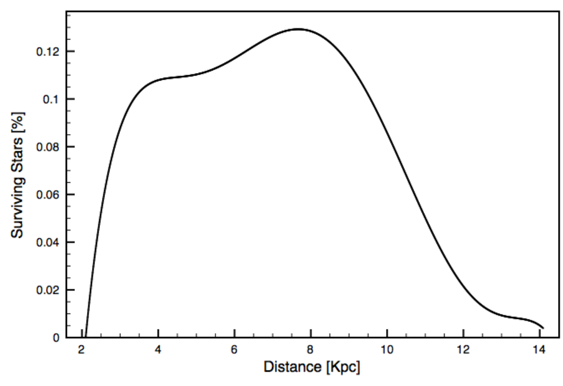
Abstract: We present a statistical analysis of the Milky Ways exoplanets. We use the Becanson galactic synthetic model to simulate the galactic and stellar habitable zones in order to calculate habitable planets.To assess habitability on the Galactic scale, we model supernova rates, planet formation and habitability on non-tidally locked planets. We found that only 0.75% of the stars in the Milky Way may possibly contain habitable planets, which makes the Galaxy practicaly empty of such planets.

1 Besancon Galactic model

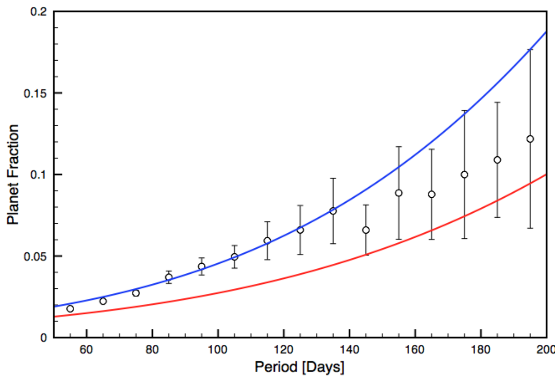
In order to simulate the stellar components of the Milky Way, we made an extensive use of the Besancon synthetic galactic model of the Milky Way assuming 200 billion stars (Robin et al. 2003 [1]). Using the stellar main sequence and white dwarf stars distribution by the Besancon model, we calculate the SN contribution for the formation of the habitable planets. 1% of white dwarfs becomes SNIa and affect the planet habitabillity in a certain distance (Figure 1a) (Gowanlock et al. 2011 [2]).

2 Kepler Statistics

In order to extract the period distribution, we are using the results from Kepler candidates excluding all hot Jupiters. The radius threshold we use is $2R_E \leq R_P \leq 8R_E$ The period distribution of the small Keplers candidates, suffers by the geometrical probability trend. After we remove the geometrical probability (Seagroves et al 2003 [3]) from Kepler candidates, we find the best Gauss fit for the upper & lower error level (Fig. 1b).



(a)



(b)

Figure 1: (a): Percentage of stars where the habitable zone survives after SN explosion. (b): Period distribution and upper - lower error limit (Kepler candidates).

3 Stellar Habitable Zone (SHZ)

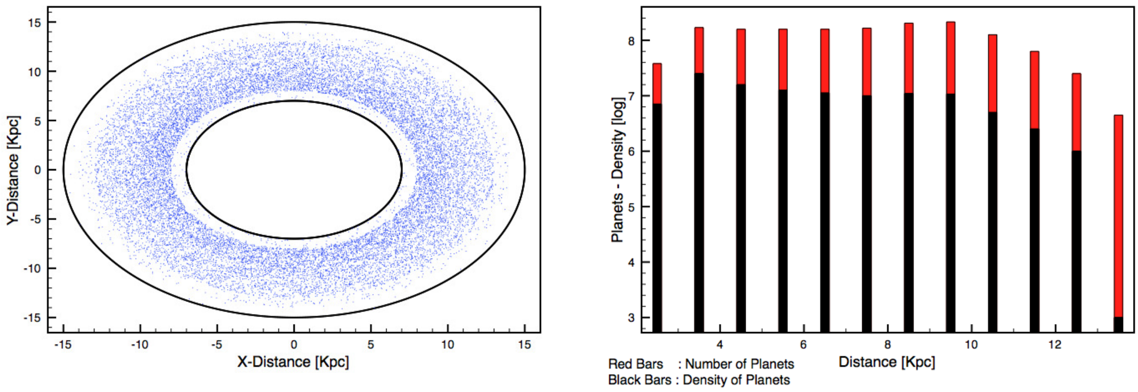
We are using the Stellar Habitable Zone (SHZ) definition by Selsis et al.(2007) [4]. Assuming that the habitable planet is covered 50% by clouds (CO2 and H2 O), the equation for the limits of the habitable zone are given by

$$d_{in,out} = (c_{in,out} - a_{in,out}T_D - b_{in,out}T_D^2)\left(\frac{L_*}{L_\odot}\right)^{0.5} \quad (1)$$

(more infrormation see the aforementioned) Monte Carlo simulations shows, that a SN threat probability increases dramatically for the inner part of the Milky Way. Thus, we agree with Gowanlock et al. (2011) [2] and Prantzos et al.(2006) [5], about the shape of the Galactic Habitable Zone (GHZ). Our simulations have shown, that a habitable planet can not be formed and survive everywhere in the Galaxy. We are using the assumption that there is at least one small planet per star (Batalha et al. 2012 [6]). As a result, in our analysis we found a total 1.4 billion habitable planets (Monte Carlo simulations) in the Milky Way. Figure 2a shows the limits of GHZ and the habitable planets candidates and figure 2b shows the total number of habitable planets and their density as a function of Galactic distance.

4 Results

Our results indicate that there are 1.4 billion habitable planets in the Milky Way, which is 0,75% of the total star population, assuming 200 billion stars. Therefore our Galaxy is nearly empty of habitable planets. The stellar distribution, stellar ages, spectral types, metallicities and distances were taken from the Besancon synthetic model. This number matches very well with Kepler results (42 candidates in the habitable zone until now versus 78 transiting habitable planets from our simulation).



(a) (b)

Figure 2: (a):The GHZ limits and the habitable planet candidates. (b): The final number of habitable planets (red bars), density (black bars).

References

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