Planetary protection in the extreme environments of low-mass stars

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The magnetic field of M dwarf stars, currently the main targets in searches for terrestrial planets, is very different from the solar one (in topology and intensity).

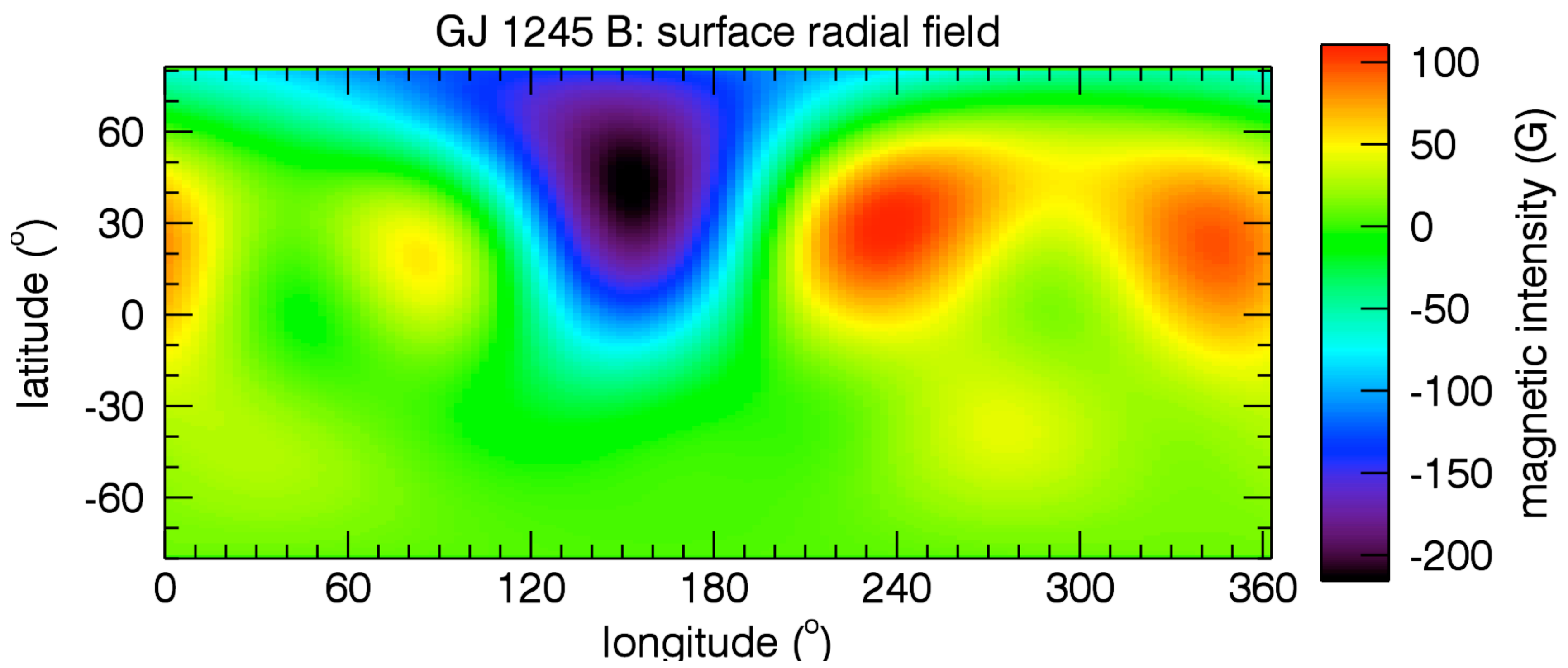

Fig.1: Observationally reconstructed surface magnetic field of a late M-dwarf star (Morin+2010).

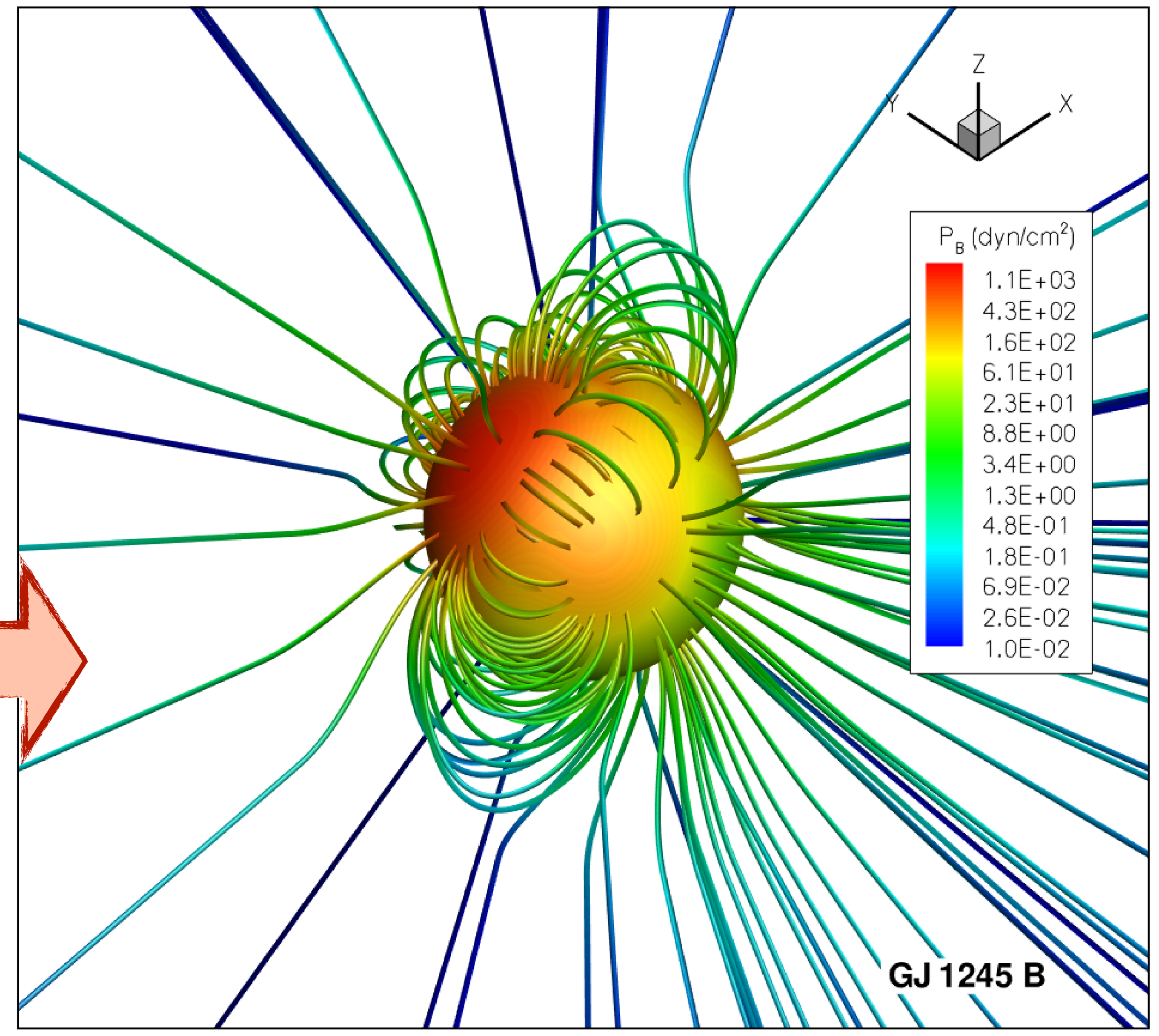

Fig.2: Stellar magnetic field lines, which is found by field extrapolations of the stellar magnetic field.

Therefore, the magnetised environment surrounding a planet orbiting in the habitable zone (HZ) of M-dwarf stars can differ substantially to the one encountered around the Earth.

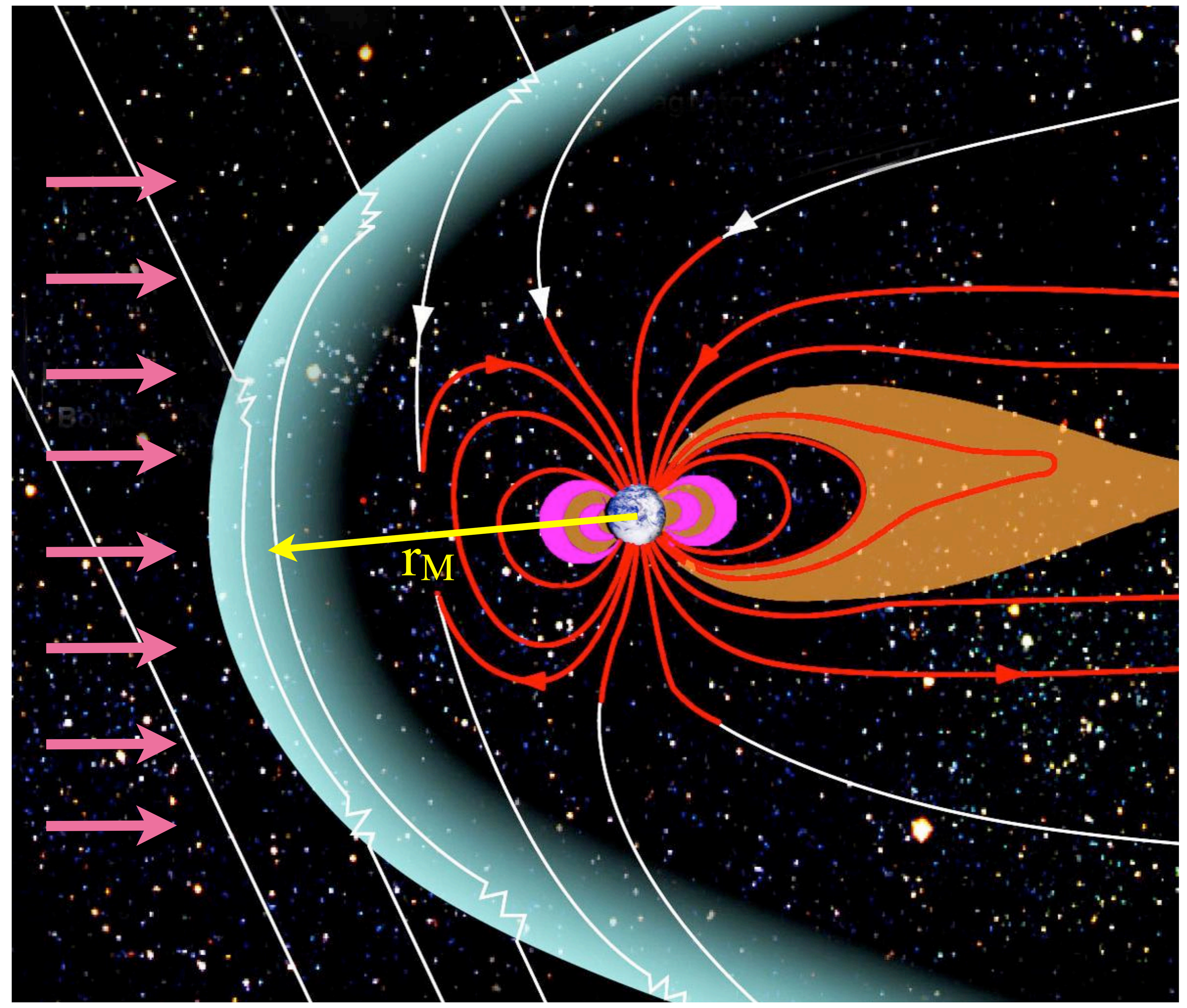

Fig.3: The solar wind ram pressure impacts on the magnetosphere of the Earth and compresses the dayside magnetosphere to $r_M \sim 12 R_\oplus$.

Likewise, the extreme magnetic pressure of M dwarfs can compress magnetospheres to such an extent that a significant fraction of the planet's atmosphere may be exposed to erosion by the stellar wind.

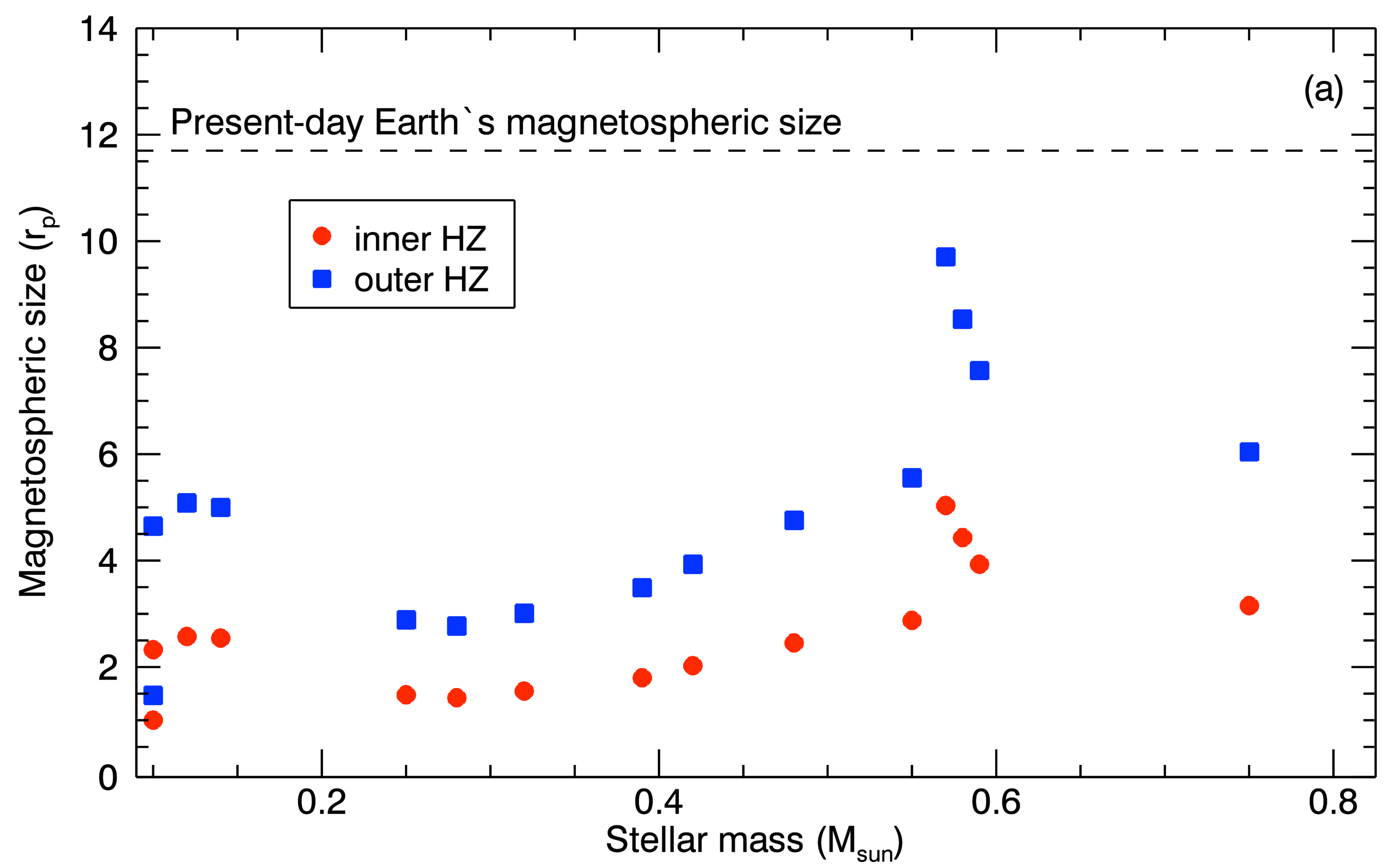

Fig.4: The minimum degree of planetary magnetospheric compression caused by the intense stellar magnetic fields for a sample of 15 M dwarf stars whose magnetic fields have been observationally reconstructed (Donati+2008, Morin+2008,2010). Hypothetical Earth-like planets with similar terrestrial magnetisation orbiting at the inner (outer) edge of the HZ of these stars would present magnetospheres that extend at most up to 5.0 r_p (9.7 r_p).

At present, it is unknown what would be the minimum degree of planetary magnetospheric compression (and for how long it is allowed to last) before it starts affecting the potential for formation and development of life in a planet.

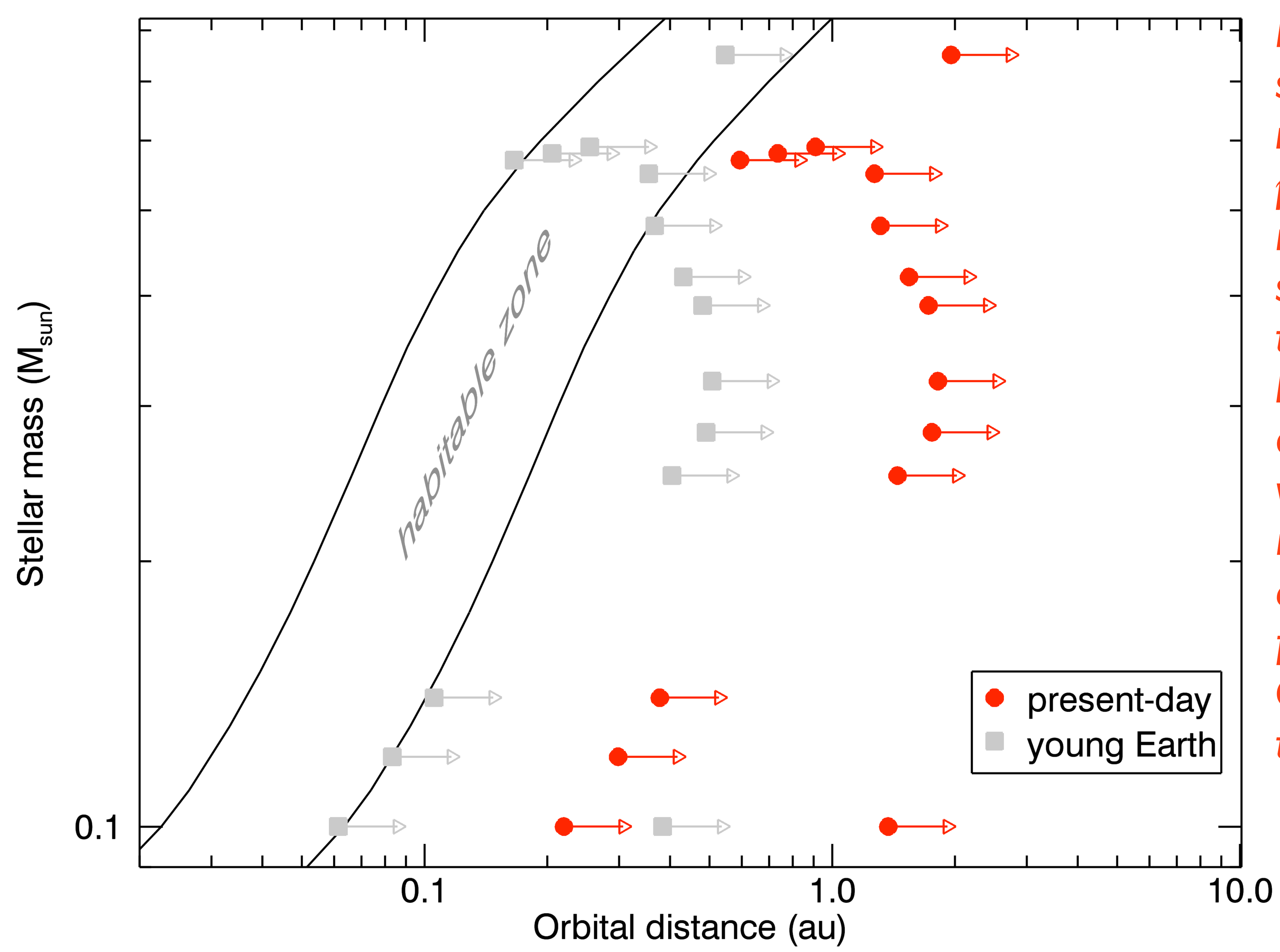

Fig.5: To be able to sustain an Earth-sized magnetosphere, such planets would either need to orbit significantly farther out than the traditional limits of the HZ; or else, if it were orbiting within the life-bearing region, it would require a minimum magnetic field ranging from a few G to up to a few thousand G.