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Inferring Stellar Activity Variations near Habitable Extrasolar Planets using Dynamical Effects

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Abstract. In this paper we have studied space weather conditions near 53 potentially habitable exoplanets reported in literature using available information on the chromoshperic activity of their host stars and nature of dynamical interactions possible in the respective star-planetary systems.

Keywords. Exoplanets, M Stars, Proxima Centauri, Dynamical Interactions, Space weather, Habitability

1. Introduction

In this paper we have studied dynamical interactions between potentially habitable exoplanets (PHEP) and its host star, in the stellar activity variation perspective. 53 potential habitable exoplanets are listed recently in (http://phl.upr.edu/projects/habitable-exoplanets-catalog) and majority of their host stars are found to be M dwarfs.

2. Results and discussion

2.1. *Space weather hazard index calculations for PHEP*

Since Earth is situated at a distance of 1 AU from the Sun, relative to the Earth, the flux from the host star to the Exoplanet varies by a factor

$$\alpha = (1/d^2) \tag{2.1}$$

where d is the distance of Exoplanet from host star in AU.

For an exoplanet situated at a distance of 0.02 AU from the host star α will be 0.25×10^4. The flux of energetic particles from stellar flares will be greater than Earth by the factor α. α is calculated and given in Table 1 for all potentially habitable exoplanets.

2.2. *Chromospheric activity of M type host stars of PHEP*

2.2.1.

The chromospheric activity of M stars with detected nearby exoplanets is found to be several times higher than our Sun. For example for GJ 667Cc the S index (Wright *et al.* 2004) is found to be 0.633 (S index of Sun is 0.1762).

2.2.2.

The occurrence rate and energy of flares in M stars like Proxima Centauri is inferred to be several times higher than that of the Sun. Super flare ($E > 10^{33}$ ergs) occurrence rate is also high in Proxima Centauri which hosts a PHEP (Davenport *et al.* 2016).

2.2.3.

The space weather hazard factor α for PHESP near M stars is found to be varying between 1 to 1260.

2.3. *Possible dynamical interactions between PHEP and their host stars*

Tidal interactions

Maximum planetary tidal force on M type host stars near PHEP typically varies between 10^3 to 10^4 kg/m^3. This is found to be in several orders higher than the solar system (maximum cumulative tidal force of all planets from the Sun is estimated to be only 11.61 kg/m^3). Flare activity observed for M stars with exoplanets may be due to tidal interaction between host stars and close planetary companions (Nisha 2015). Proxima Centauri is a part of the triple star system so that tidal forces due to its stellar companions to be considered apart from the planetary tides on its discussing its extraordinary flare activity.

Angular momentum exchanges between PHEP and their host stars

The centre of mass of the typical host stars with exoplanets similar to Table 1 is found to be closer to the star centre. The offsets are typically only 10^{-4} to 10^{-5} AU for PHEP systems near M stars. In the case of solar system significant portion of the centre of mass is with the planets and the centre of mass can vary to a value greater than 1 solar radii. The offset of the centre of mass of star planetary system from the centre of host star will enhance the possibility of angular momentum exchanges in the star planetary system (Aranya 2017). It appears that tidal interactions will have a greater role for the host stars near PHESP.

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