Investigating the impact of space weather on the habitability of exoplanet around M-dwarf star as a case study using TESS observation

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ABSTRACT

The stellar flares are the explosive magnetic reconnection events in the star's magnetosphere they also play a crucial role in building up the habitability parameters. By studying the light curves we can measure the depth of the dip and from that, we can determine the size or radius of the planet. And by looking at the stellar flares in those light curves we can calculate the flare frequency and flare energy

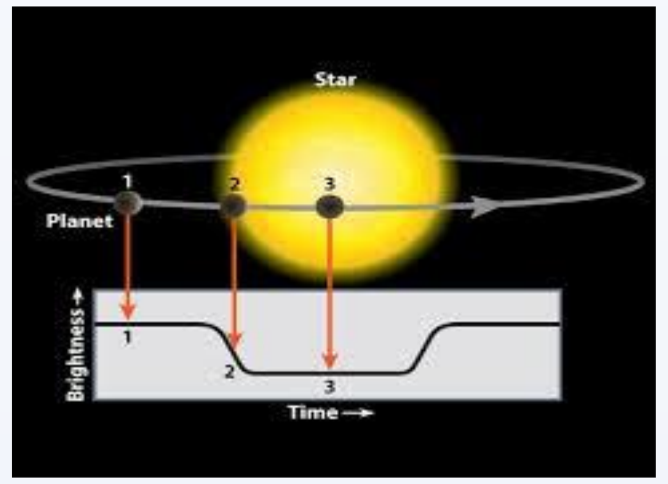

Fig.1 Light curve of a planet transiting its star , NASA

Objectives

TESS Mission TESS is a two-year all-sky survey mission and will focus on nearby G, K, and M-type stars. The survey is broken into 26 observation sectors. The spacecraft will spend two 13.7 day orbits observing each sector mapping the southern hemisphere of the sky in its first year of operation and the northern hemisphere in its second year Approximately 200,000 stars will be studied including 1000 closest red dwarfs across the whole sky

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Package used

Package used: AltaiPony is a toolbox for statistical flare studies in photometric time series from Kepler, K2, and TESS, including flare search and characterization, injection/recovery diagnostics, and statistical analysis of flare frequency distributions.

Space weather and Stellar activity

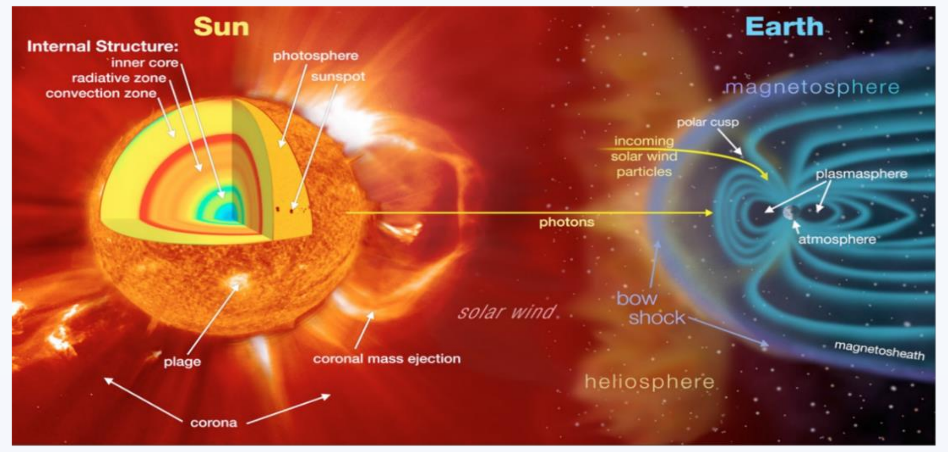


Fig.2 Space weather around the Earth.

Space weather is a general term that applies to the environmental conditions in space imposed by stellar activity such as the "wind" of subatomic particles that constantly flow from the Star. This stellar wind sometimes rages into a "storm" of charged particles (mostly electrons and protons) that can affect, disturb the habitability parameters of its planets. CME involves gigantic explosions of energy. They are highly energetic particles like cannonball propelled forward in a single preferential direction

What Is a Stellar Flare ?

Stellar flares are the release of magnetic energy in stellar spots exploding in an intense burst of electromagnetic radiation that can be observed across the entire electromagnetic spectrum, from radio waves to gamma rays.

A magnetically active star is a flaring star. The motion of the star's interior controls its own magnetic field. Star's that are known for flaring are mostly M dwarfs, also known as ultra-cool dwarf stars. Whereas CME involves gigantic explosions of energy. They are highly energetic particles like cannonball propelled forward in a single preferential direction .

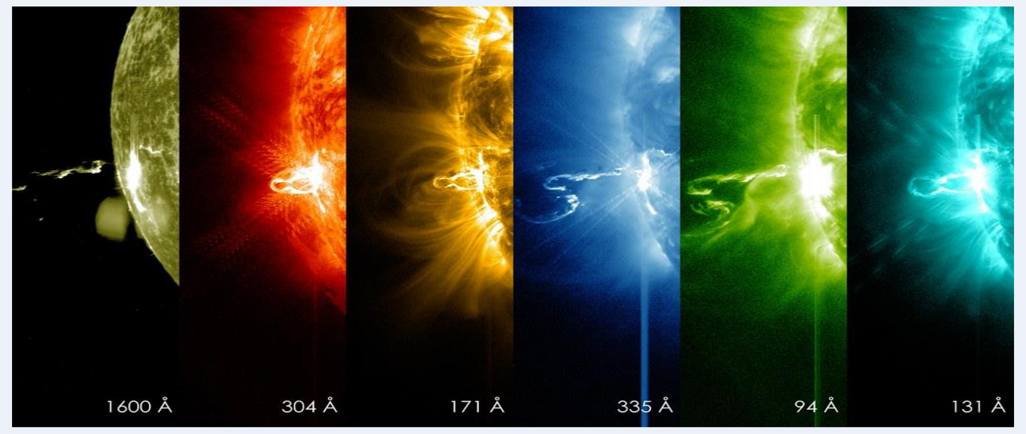
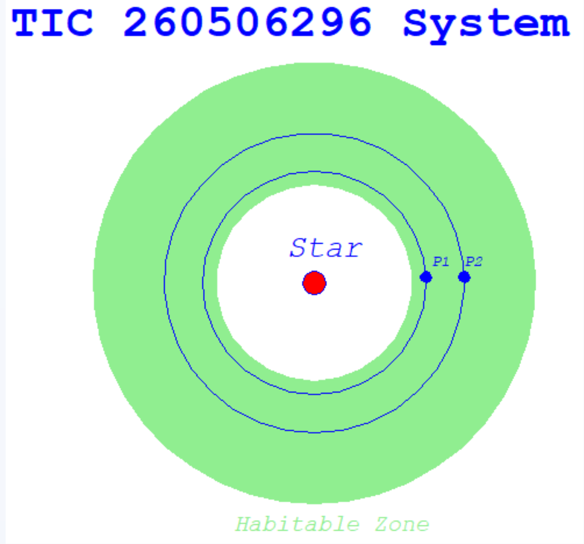


Fig .3 First moments of Solar flare in different wavelengths of light, NASA

Orbits of the planets in the habitable zone region around the star



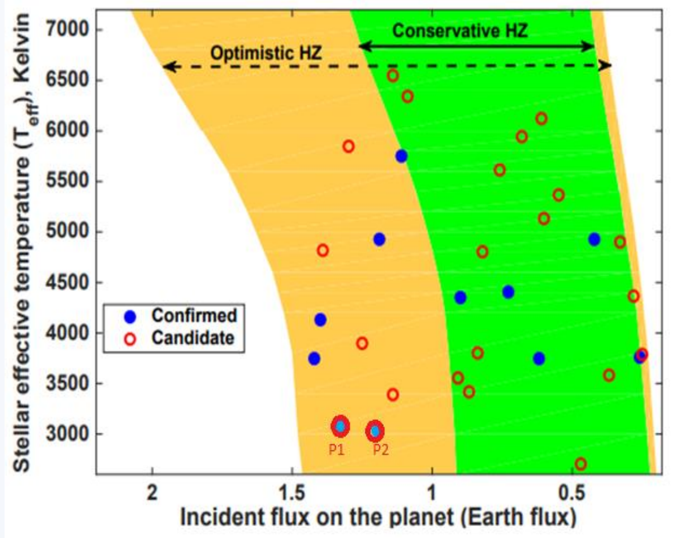


Fig.4 TIC 260506296 System with its Habitable Zone and candidate planets.

Fig. 5 Habitable zones of M, K, G stars and confirmed/candidate planets.[3]

What makes a planet habitable?

The availability of liquid water is the most important factor that makes a planet habitable because water is a very effective polar molecule and hence an excellent solvent and facilitator for the complex chemistry of life. M dwarfs are of primary interest in the search for habitable exoplanets for several reasons. First, they constitute a large fraction (70%) of the stellar population. Their small radii and low temperatures enable the detection and atmospheric characterization of habitable planets on short orbits.

Data Analysis

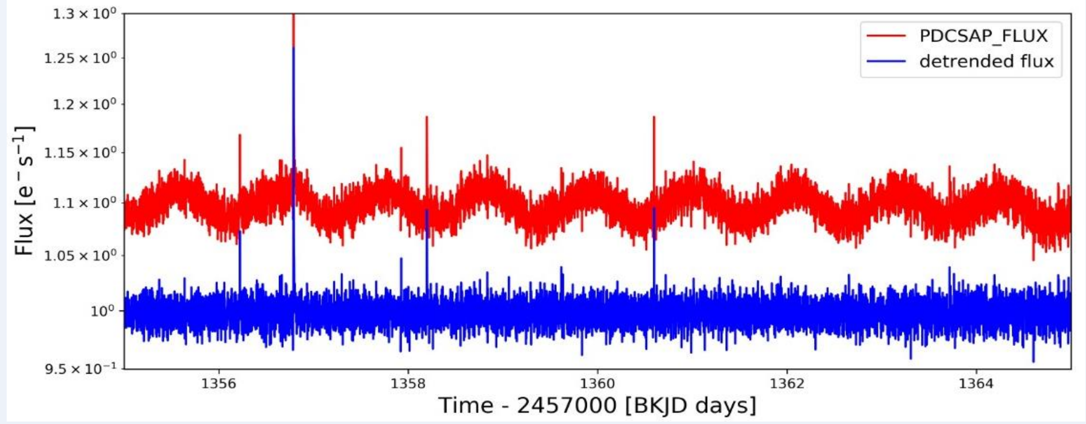


Fig. 6 Normalized detrended light curve

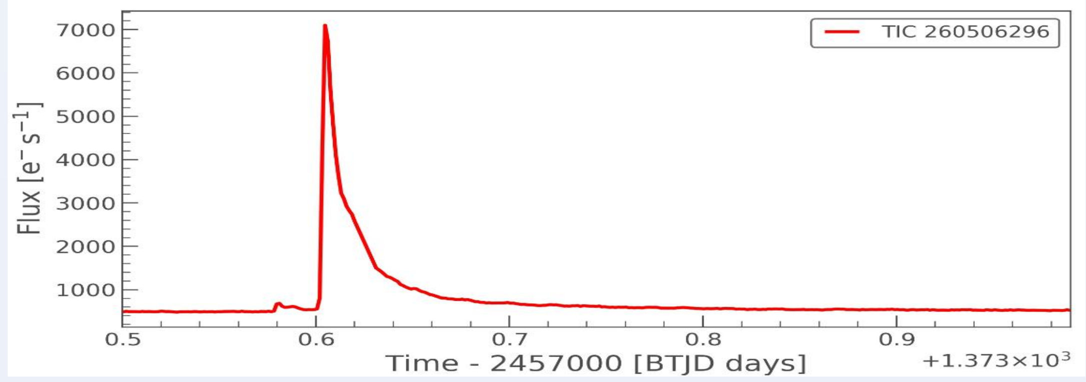


Fig.7 The largest stellar flare observed on the host star

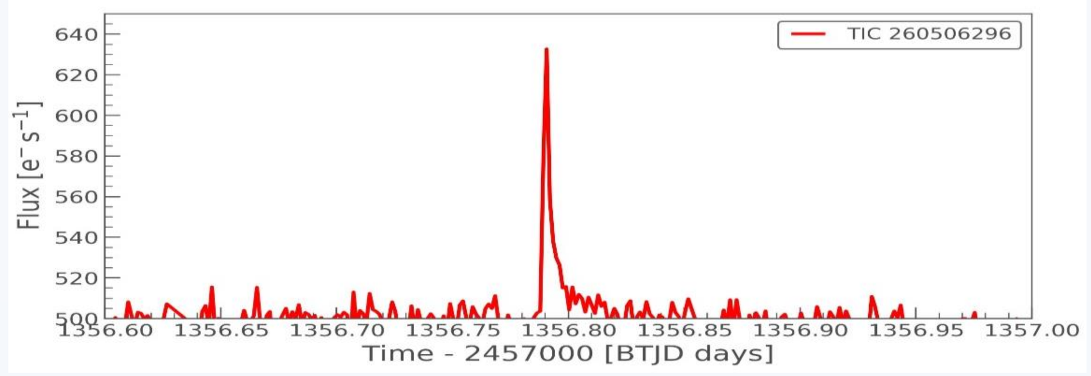


Fig.8 The second flare of the same star

Derived parameters:

Stellar flux: 5.86×10^{6} W/m^2

Stellar flux at planet 1: 1845.80 W/m^2

Stellar flux at the planet 2: 1636.29 W/m^2

Habitable zone boundary: 0.115 A.U

Middle habitable zone: 0.1128 A.U

Flare Energy: 1.518 x 10^{37}erg (Largest flare),

where EU = 7 % Eflare

EU = 1.0626 x 10^{34} erg

Flare energy for the second-highest flare : 5.517 x 10^{34} erg

EU = 3.86 x 10^{31} erg

CME_1 = 1.484 x 10^{22} g

CME_2 = 2.594 x 10^{20} g

Discussion and Conclusion

Super flares are said to be significantly affecting the habitability of potential exoplanets which lie in the habitable zone around M - dwarf host stars. Such super flares with sufficient energy over a course of time can trigger reactions that can lead to the inventory of prebiotic chemistry on nearby exoplanets.

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