THE HABITABLE EXOPLANET HUNTING PROJECT

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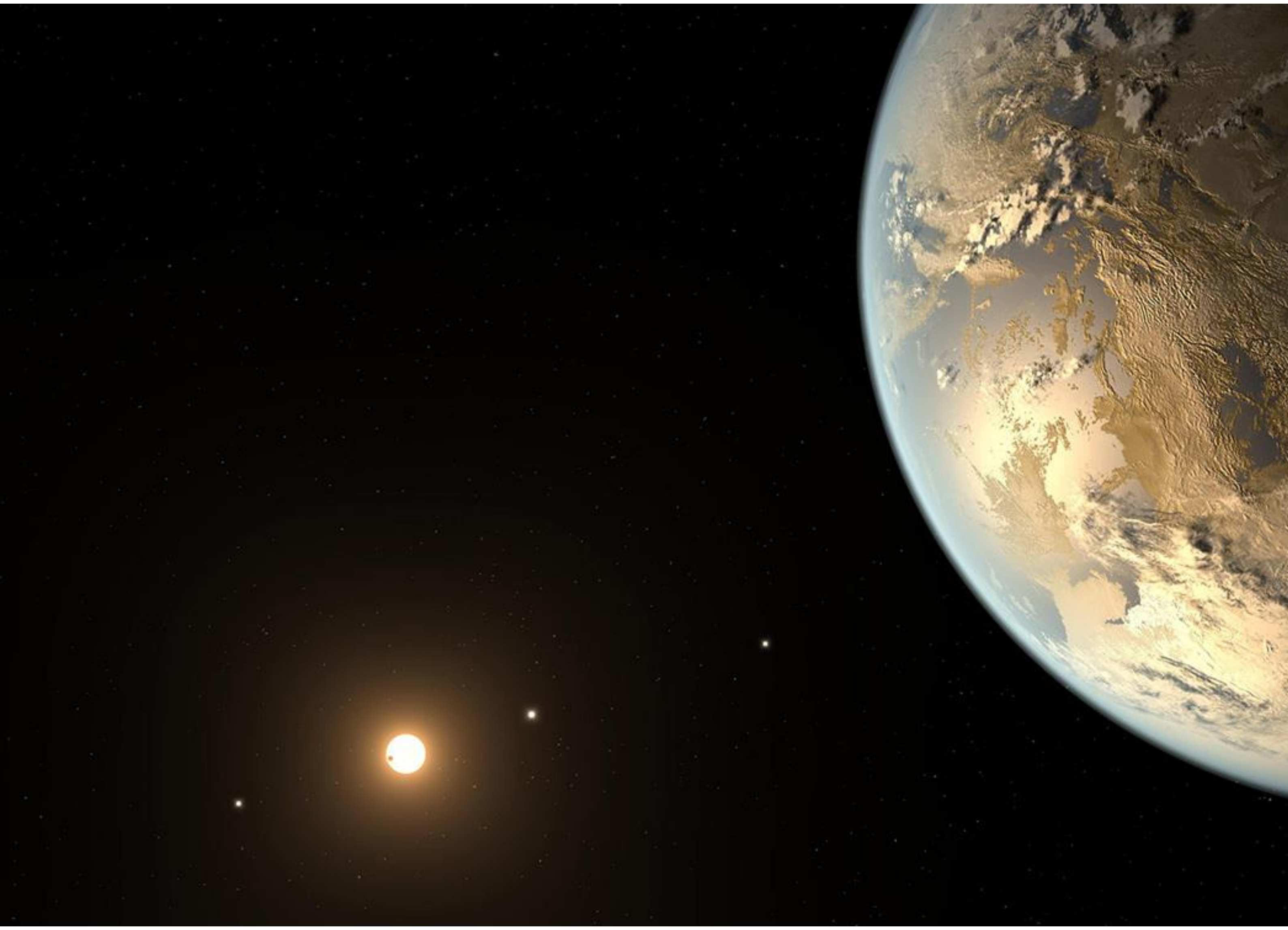

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1. What is the Habitable Exoplanet Hunting Project?

The Habitable Exoplanet Hunting Project is a proposed project to enable amateurs to discover more potentially habitable exoplanets, specifically around non-flare G-like stars, K-type stars and red dwarfs, within 100 ly. These stars would have known transiting exoplanets outside the habitable zone or non-rocky exoplanets inside.

The idea is to create a group of amateur exoplanet hunters belonging to organizations such as the TRESCA (TRansiting ExoplanetS and CAndidates) community, organized by the Variable Star and Exoplanet Section of the Czech Astronomical Society and composed by 191 observatories.

The American Association of Variable Star Observers (AAVSO) is another organization where amateur astronomers could be interested in joining the project. The AAVSO currently has over 1,000 members.

Overall, the monitoring of a specific star or stars at a specific time every week would be assigned to each of the astronomers or observatories.

As of March 2019, only one potentially habitable exoplanet has been discovered with the help of an amateur astronomer (Thiam-Guan) using the transit method: LHS 1140 b, located 41 light years away.

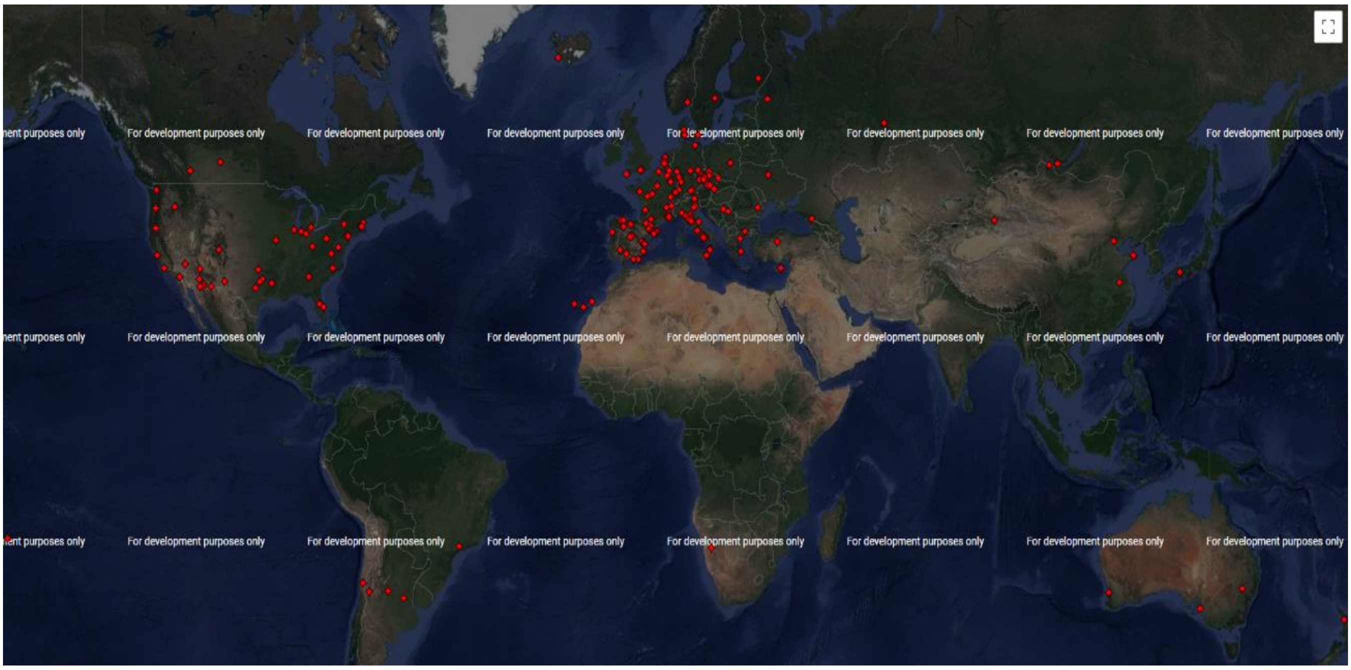

Figure 1- TRESCA observers community map

2. Why is it needed?

The Kepler Space Telescope and K2 campaigns focused on a reduced part of the sky, each of them only lasting 80 days.

The TESS telescope will monitor 85 % of the sky, but continuously for just 27 days. Only 5% of the entire sky is monitored all the time.

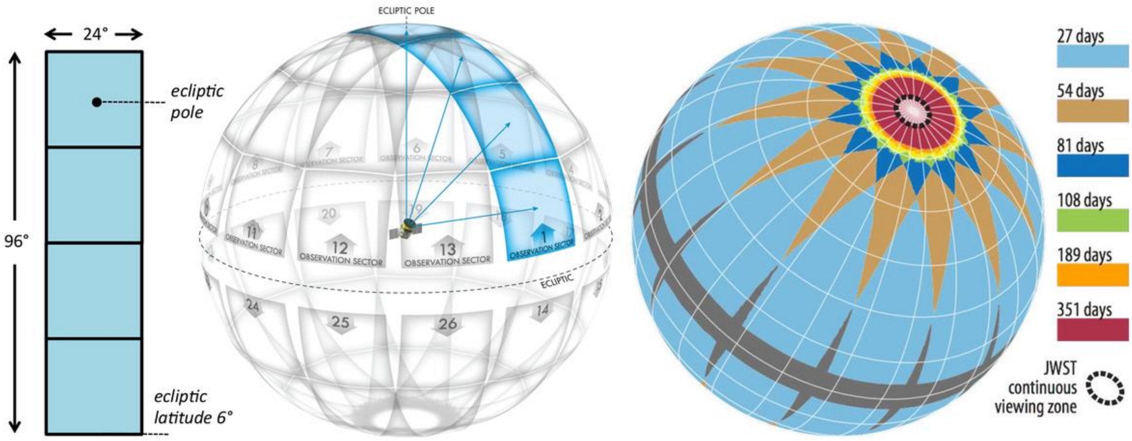

Figure 2 - Observation sectors of the sky planned for TESS

For G and K-type stars, 80 and 27 days of continuous monitoring implies that most of the possible transits by potentially habitable exoplanets would be missed.

Exoplanet hunting projects such as WASP and HATNet have proved successful, but only WASP has been able to discover one rocky exoplanet and none of them have discovered potentially habitable exoplanets as of March 2019. Moreover, WASP only monitors stars of magnitude 8 to 13, therefore missing possible transits in G-type and red dwarfs. Similarly, HATNet uses 200mm-aperture lenses that might not be able to catch transits coming from red dwarfs.

The purpose of The Habitable Exoplanet Hunting Project is to focus on specific stars that might have habitable exoplanets and gather data 24/7 during all the time (weeks, months) that a transit could theoretically occur.

3. What results could be obtained?

So far, only one potentially habitable exoplanet has been discovered around a G-type star within 100 light years and another potentially habitable exoplanet around a K-type stars at the same range of distance.

Considering that there are as many as 508 G-type non-flare stars within 100 light years and around 0.5% of the them should show transits in the habitable zone, amateur astronomers could be able to detect the hypothetical number of 1,5 more potentially habitable planets (without including the one already discovered). For the case of Super-earths around G-type stars, the transit depth is 0.05%.

Transit depth = (radius of the planet / radius of the star) ^2

D = (radius of a Super-earth / radius of the Sun) ^2

D = (2.5 x 6,371 / 695,510) ^2 = 0.0005 = 0.05%

*2.5 times the size of Earth (optimistic sample)

Similarly, considering that there are as many as 937 K-type non-flare stars within 100 light years and around 0.7% of them (for the case of Kepler 442-b) should show transits in the habitable zone, amateurs could be able to detect 5.5 more potentially habitable planets (some of them might be even super-habitable).

Transit probability = radius of the star / semimajor axis length

T = radius of the K-type star Kepler 442 / semimajor axis length of Kepler 442-b

T = 0.6 x 0.00465 au / 0.4 = 0.007 = 0.7%

*0.6 times the size of the Sun

For the case of Super-Earths like Kepler 442-b around K-type stars, the transit depth is 0.06%.

With respect to red dwarfs, considering that there are as many as 1,939 M-type non-flare stars within 100 light years and around 1% of them (for the case of LHS 1140 b) should show transits in the habitable zone, amateurs could be able to detect 18 more potentially habitable exoplanets. For the case of Super-Earths like LHS 1140 b around red dwarfs, the transit depth is 0.6%.

For observing sessions of 1 hour, it would be possible to capture half the transit of exoplanets around red dwarfs with sufficient OOT time. In any case, the observatories would have to exchange data when necessary and if a possible transit is spotted, a full observation of the target would be conducted during the next transit.

Overall, the number of potentially habitable exoplanets that could be discovered could be 25. This is a large number considering that only 49 potentially habitable exoplanets have been discovered as of March 2019.

4. How could it be organized?

Each astronomer would only have to gather data from the star around 1 hour per week. This calculation was obtained by multiplying 24 hours x 7 days and dividing the result by the 191 observatories.

To make the process easy, the observations would be conducted at the same local time of the astronomers. For those cases when there is no observatory in a specific time zone, the observations would be assigned to the closest observatory. Adjustments would also have to be made on real time to exchange observation days when skies are cloudy. In addition, considering that most of the observatories are located in the Northern hemisphere, the Southern hemisphere observatories would have to undertake more hours of observation; for that, it would be ideal the use of robotic telescopes. Getting help from Southern AAVSO observatories could also solve the problem.

The project is intended to target one star at a time. Once it is unlikely that a transit of a potential exoplanet takes place, a new star would be assigned. To calculate the maximum possible orbital period of a hypothetical exoplanet, Kepler's Third Law would be applied to the default outer boundary of the habitable zone.

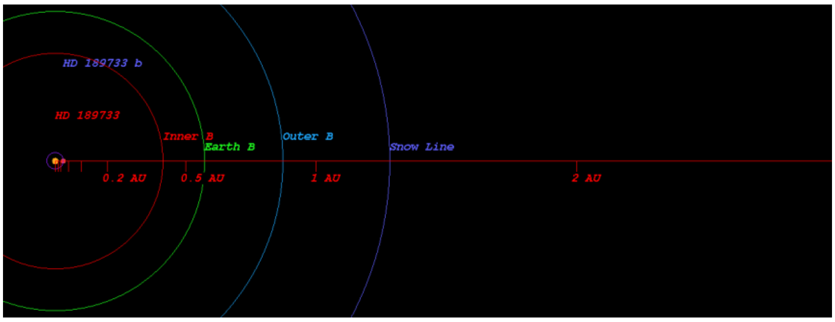

Figure 3 - Habitable zone calculated based on SEAU (Solar Equivalent Astronomical Unit) around the star HD 189733

It would also be possible to conduct observations on several stars at the same time. In that case, each observatory would have to spend an average of 8 hours of observation per week (which might actually be the duration of any astronomer's night session). This was calculated by multiplying 24 hours x 7 days x 9 stars (selected below) and dividing the result by the 191 observatories.

For the assignation and re-assignation of targets and observation times, an interactive network could be built inside the Exoplanet Transit Database. As an alternative, a forum has been created for the observation of one star at a time: https://exoplanetschannel.wixsite.com/home/forum. The selection of the general local time to conduct the observations could be done by voting.

5. What stars could be targeted?

List of the 9 non-flare G, K and red dwarf stars within 100 light years with known transiting exoplanets and no rocky exoplanets in the habitable zone (as of March 2019):

STAR	TYPE	MAGNITUDE	CONSTELLATION	Nº OF PLANETS
HD 189733 A	K	7.7	Vulpecula (northern)	1
GJ 3470	M	12.3	Cancer (northern and southern)	1
GJ 436	M	10.7	Leo (northern and southern)	1
HD 97658	K	6.3	Leo (northern and southern)	1
GJ 9827	K	10.2	Pisces (northern and southern)	3
55 Cnc A	G	6	Cancer (northern and southern)	5
LHS 3844	M	15.2	Indus (southern)	1
K2-129	M	13.6	Sagittarius (southern)	1
Pi Men	G	5.6	Mensa (southern)	2

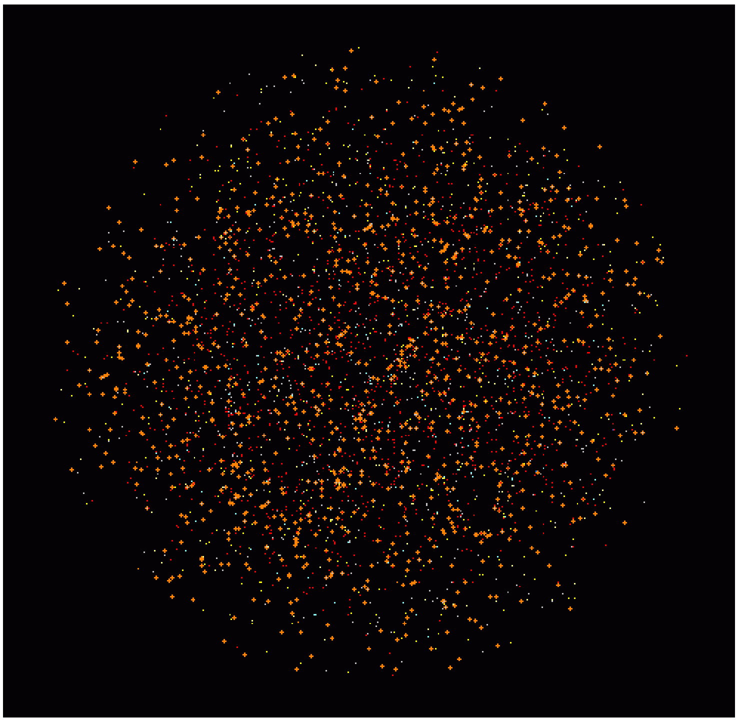

Figure 4 - K stars within 100 light-years

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