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Characterising the Atmospheres of Transiting Planets with a Dedicated Space Telescope

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Abstract

Transiting super-Earths orbiting M dwarfs are excellent targets for the prospect of studying potentially habitable extrasolar planets. While most of the currently known Exoplanets are of the Hot Jupiter and Neptune type, attention is now turning to these super-Earths. Two recent examples are GJ 1214b, found by Charbonneau et al. in 2009, and Cancri 55 e, found by Winn et al. in 2011. These candidates offer the opportunity of obtaining spectral signatures of their atmospheres in transiting scenarios, via data obtained by ground based and space observatories, compared to simulated climate scenarios. With the recent selection of the Exoplanet Characterisation Observatory (EChO) mission by ESA for further studies, I present observational strategies and time requirements for a range of targets characterisable by EChO, with a view to super-Earths orbiting M dwarfs.

1. Introduction

The science of extra-solar planets is one of the most rapidly changing areas of astrophysics, a combination of ground-based surveys and dedicated space missions has resulted in 550 plus planets being detected (exoplanet.eu, May 2011), and over 1200 that await confirmation [1]. NASA's Kepler mission has opened up the possibility of discovering Earth-like planets in the habitable zone around some of the 100,000 stars it is surveying during its 3 to 4-year lifetime. The new ESA's Gaia mission is expected to discover thousands of new planets around stars within 200 parsecs of the Sun [2]. Meanwhile, transit and combined light methods have allowed the characterisation of the atmosphere of a few hot large bodies close to their star using current space telescopes, e.g. [3, 4, 5, 6] and ground based telescopes [7]. Transiting hot super-Earths, while being very interesting targets since they are absent from our Solar System, are within reach with current telescopes, e.g. GJ 1214b [8], and Cancri 55 e.
We consider the possibilities offered by a 1.4 m space based telescope capable of performing spectroscopy from the visible down to the Mid-IR. Such a mission concept has most recently been selected for an assessment study by ESA, under the name Exoplanet Characterisation Observatory (EChO) (Tinetti (2011), *submitted*).

2. Results

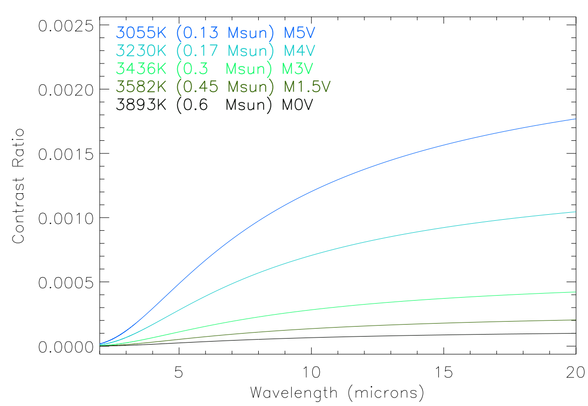

Figure 1: Emission from a 1.6 $R_\oplus$ hot super-Earth, presented in orbit of five M stars (T=3055-3893 K)

Using the transit technique, in primary transit (where a planet passes its star by our line of sight), and/or secondary eclipse (where a planet transits behind its star, but is fully illuminated before and after), spectroscopy can be used to characterise distant exoplanets. We present here a few key cases from our study, which assumes a 1.4m space based telescope, listing integration times (as "number of tran-

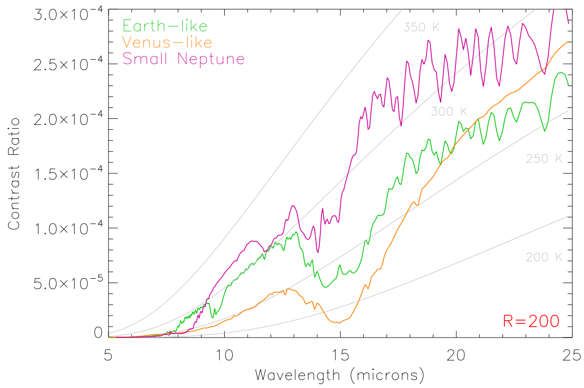

Figure 2: Emission from a 1.8 $R_\oplus$ HZ super-Earth in orbit of a M4.5V star, with three plausible atmospheres: Earth, Venus and small-Neptune like

sits", delimited by the length of the mission divided by the orbital period duration) for a range of planets and stars (with magnitude in K from 5 to 9) in Table 1, with examples in primary transit and secondary eclipse. The cases we present are hot and habitable-zone (HZ) super-Earths (with radii 1.6-1.8 $R_\odot$), for which we also show two planet/star flux contrast plots (Figures 1 and 2). From these figures we compute integration times for each target/star combination using our simulation software, which takes into account parameters such as: stellar properties, observing band, spectral resolution, SNR, instrument and detector performances. In addition, we provide integration times for a primary transit event of GJ 1214b. Other cases are also included in our study, but not shown here. A brief selection: hot Jupiters in the orbit of bright stars, warm Neptune-like planets in the orbit of M dwarfs (with the example of GJ 436b), HZ Jupiters.

3. Summary and Conclusions

We have presented a small sample of targets from our study: hot and HZ super-Earths in secondary eclipse observation and a warm super-Earth in a primary transit scenario. Our full results will be presented in Tessenyi *et al.*, submitted. The results of our studies highlight that in the coming years the characterisation of habitable-zone super-Earths are realistically within reach, with a small space-based spectroscopy telescope, such as EChO.

References

[1] Borucki et al. Nature, 2010.

[2] Sozzetti, A. The Gaia astrometric survey. Highlights of Astronomy, 15:716-717, 2010

[3] Charbonneau, D., Brown, T. M., Noyes, R. W., and Gilliland, R. L. Detection of an extrasolar planet atmosphere. astro-ph/0111544. Astrophys.J. 568 377-384, 2002.

[4] Tinetti, G., Liang, M. C., Vidal-Madjar, A., Ehrenreich, D., des Etangs, A. L., and Yung, Y. ApJ, 654:L99, 2007.

[5] Beaulieu, J. P., Carey, S., Ribas, I., and Tinetti, G. Primary transit of the planet HD189733b at 3.6 and 5.8 microns. 0711.2142. Astrophys.J.677:1343-1347, 2008.

[6] Swain, M., Vasisht, G., Tinetti, G., Bouwman, J., Pin Chen andYung, Y., Deming, D., and Deroo, P. ApJ, 960:L114, 2009b.

[7] Redfield, S., Endl, M., Cochran, W. D., and Koesterke, L. (2007). Sodium absorption from the exoplanetary atmosphere of HD189733b detected in the optical transmission spectrum. 0712.0761.

[8] Charbonneau, D., Berta, Z. K., Irwin, J., Burke, C. J., Nutzman, P., Buchhave, L. A., Lovis, C., Bonfils, X., Latham, D. W., Udry, S., Murray-Clay, R. A., Holman, M. J., Falco, E. E., Winn, J. N., Queloz, D., Pepe, F., Mayor, M., Delfosse, X., and Forveille, T. (2009). A super-Earth transiting a nearby low-mass star. 0912.3229.

Table 1: Integration times for super-Earths with a 1.4m space telescope

Star type	T (K)	R ($R_\odot$)	Contrast ($*10^{-4}$)	Period (days)	$\tau_{transit}$ (hours)	Max. n* (transits)	Integration time (n. transits) *mag.*:K=5	K=6	K=7	K=8	K=9
M1.5V	3582	0.42	1.4	1.22	1.1	1494	13	33	87	236	707
M3V	3436	0.30	2.9	0.79	0.8	2300	4.2	11	28	75	225
M5V	3055	0.16	12.2	0.25	0.4	7450	0.5	1.2	3.1	8	25
Abobe: Hot super-Earths (850 K) –Secondary eclipse. R=40, SNR=10, mid infrared											
M4.5V	2949	0.21	27	1.58	0.88	1155	0.1	0.1	0.3	0.8	2.3
Abobe: Warm super-Earth (500 K) –example of GJ1214b in primary transit, R=40, SNR=10, mid infrared											
M3V	3436	0.30	1.4	23	2.4	79	36			*photometry*	
	3380	0.26	1.9	19.3	2.1	94	22	55		*photometry*	
M4V	3230	0.20	3.5	12.7	1.5	143	9	23	58	149	*ph.*
	3150	0.17	4.6	10.7	1.3	170	6	15	39	101	*ph.*
M5V	3055	0.16	6	8.7	1.2	209	3.9	10	25	65	172
	2920	0.14	8.5	6.7	1	272	2.4	6	15	39	104
Abobe: Habitable Zone super-Earth (300 K) –Secondary eclipse, R=10, SNR=5, mid infrared											