Transiting Exoplanets Project Proposal

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February 2022

1 Summarised plan

The overarching goal of this project is to determine whether any exoplanets exhibit transit timing variations, and attempt to measure that variation using a mix of historical data and observations that I will carry out over the course of this project.

My own observations will be made with the 24" Ritchey-Chrétien telescope at clanfield observatory, and analysed using the HOPS software maintained by Exoworldspies. This software will allow me to determine properties of the transit, such as occlusion depth and transit period, that can inform my understanding of the physical parameters of the system. I will also upload my own observations to the Exoclock website, to expand upon historical ephemeral data.

Transit timing variations will be extracted from historical lightcurve data using a set of python scripts that I will write over the course of this project. If transit timing variations are found for any systems, I will attempt to determine the parameters of additional planets within the system and so derive a model of the system. This solution can be compared against both n-body simulation and published literature to determine the accuracy of my model.

2 Observation target selection

To narrow down the thousands of exoplanet systems to something more feasible, a query was made to the NASA Exoplanet Archive for planets that matched the following criterion:

- The system contains a single star, and at least two planets.
- At least one of the planets was discovered by Transit method.
- The system must have Right Ascension between 4h and 15h. This places it 6.5 hours either side of the Sun (as of 2022-02-07), and ensures the planet is visible at night time.
- The system must have declination greater than zero.
- The central Star must have a visual magnitude smaller than 15.

Name	Observations ExoClock / ETD	Right Ascension hh:mm:ss	Declination dd:mm:ss	Visual Magnitude mag	Transit Depth mmag
HAT-P-13 b	11 / 109	08:39:31.81	+47:21:07.26	10.40	8.25
HAT-P-44 b	10 / 43	14:12:34.57	+47:00:53.05	12.83	24.45
HD 63433 b	0 / 0	07:49:55.06	+27:21:47.46	6.49	0.62
HD 63433 c	0 / 0	07:49:55.06	+27:21:47.46	6.49	0.90
HD 63935 b	0 / 0	07:51:41.99	+09:23:09.79	8.10	1.02
HD 63935 c	0 / 0	07:51:41.99	+09:23:09.79	8.10	0.08
HIP 41378 e	0 / 0	08:26:27.85	+10:04:49.33	8.62	1.71
HIP 41378 f	0 / 0	08:26:27.85	+10:04:49.33	8.62	5.72
K2-18 b	0 / 0	11:30:14.52	+07:35:18.26	13.24	3.49
K2-19 b	0 / 0	11:39:50.48	+00:36:12.88	12.88	7.63
K2-19 c	0 / 0	11:39:50.48	+00:36:12.88	12.88	7.63
K2-36 c	0 / 0	11:17:47.78	+03:51:59.01	11.48	1.6
K2-155 c	0 / 0	04:21:52.48	+21:21:12.94	12.46	1.39
K2-239 b	0 / 0	10:42:22.63	+04:26:28.89	14.14	0.86
KELT-6 b	2 / 1	13:03:55.65	+30:38:24.28	10.00	7.89
TOI 561 b	0 / 0	09:52:44.55	+06:12:58.92	9.78	0.31
TOI 561 c	0 / 0	09:52:44.55	+06:12:58.92	9.78	1.27
TOI 1266 c	0 / 0	13:11:59.56	+65:50:01.70	12.58	1.44
TOI 2076 b	0 / 0	14:29:34.24	+39:47:25.54	8.66	2.06
V1298 Tau b	0 / 0	04:05:19.59	+20:09:25.56	9.57	6.29
V1298 Tau c	0 / 0	04:05:19.59	+20:09:25.56	9.57	1.93
V1298 Tau d	0 / 0	04:05:19.59	+20:09:25.56	9.57	2.56
V1298 Tau e	0 / 0	04:05:19.59	+20:09:25.56	9.57	4.67

Table 1: List of planetary candidates that are in the Exoclock Database alongside the number of transit observations that have been recorded in both Exoclock and the Exoplanetary Transit Database. Exoplanets are coloured where their transit depth exceeds 5mamg (dark blue), 10mmag (blue), or 20mmag (light blue).

There were 85 planetary candidates returned by this query. Of those 85, 23 were also listed in the exoclock database, and are summarised in table 1.

Of the initial 85 candidates, 7 were flagged in the exoplanet archive as exhibiting Transit timing variations, shown in table 2.

Name	Right Ascension hh:mm:ss	Declination dd:mm:ss	Visual Magnitude mag
HAT-P-13 b	08:39:31.77	+47:21:06.87	10.421
HIP 41378 c	08:26:27.80	+10:04:49.33	8.930
K2-19 b	11:39:50.46	+00:36:12.95	13.024
K2-19 c	11:39:50.46	+00:36:12.95	13.024
K2-19 d	11:39:50.46	+00:36:12.95	13.024
TOI-1266 b	13:11:59.18	+65:50:01.31	12.941
TOI-1266 c	13:11:59.18	+65:50:01.31	12.941

Table 2: List of planetary candidates that were flagged as exhibiting transit timing variation

3 Observational Windows

Observational windows in February, March, and April for observable planets is given in table 3.

Table 4 shows a shortened list of proposed observations to be considered. These observational window include an hour either side of the transit event for calibration and setup.

Name	Source	Transit Start	Transit End
HAT-P-13 b	Exoclock	2022-02-19 01:37	2022-02-19 04:56
HAT-P-44 b	Exoclock	2022-02-21 22:56	2022-02-22 03:09
HAT-P-13 b	Exoclock	2022-02-21 23:37	2022-02-22 02:56
HAT-P-13 b	Exoclock	2022-02-24 21:36	2022-02-25 00:56
HAT-P-13 b	Exoclock	2022-02-27 19:36	2022-02-27 22:55
HAT-P-44 b	Exoclock	2022-03-06 20:37	2022-03-06 23:49
K2-19 b	Exoclock	2022-03-09 23:34	2022-03-10 03:03
K2-19 b	Exoclock	2022-03-17 21:38*	2022-03-18 01:07
KELT-6 b	ETD	2022-03-20 00:55*	2022-03-20 06:26
HAT-P-44 b	Exoclock	2022-03-24 01:31	2022-03-24 04:44
K2-19 b	Exoclock	2022-03-25 19:42	2022-03-25 23:11
KELT-6 b	Exoclock	2022-03-27 20:39	2022-03-28 02:31
HAT-P-13 b	Exoclock	2022-03-28 23:33	2022-03-29 02:52
HAT-P-13 b	Exoclock	2022-03-31 21:33	2022-04-01 00:52
HAT-P-13 b	ETD	2022-04-03 19:38	2022-04-03 22:51
KELT-6 b	ETD	2022-04-04 17:30	2022-04-04 23:01
HAT-P-44 b	Exoclock	2022-04-05 23:13	2022-04-06 02:25
HAT-P-44 b	Exoclock	2022-04-18 20:54*	2022-04-19 00:07

Table 3: Observational windows for planets with TTV flags or transit depths greater than 5mmag, where dates marked with an asterisk occur within two days of the full moon
Additionally: red font indicates a time late at night, while orange indicates observations that require pointing the telescope north or north east, and would require assessing the risk of the telescope impacting its mount.

Name	Source	Observation Start	Observation End
HAT-P-13 b	Exoclock	2022-02-24 20:36	2022-02-25 01:56
HAT-P-13 b	Exoclock	2022-02-27 18:36	2022-02-27 23:55
HAT-P-44 b	Exoclock	2022-03-06 19:37	2022-03-07 00:49
K2-19 b	Exoclock	2022-03-17 20:38*	2022-03-18 02:07
K2-19 b	Exoclock	2022-03-25 18:42	2022-03-26 00:11
HAT-P-13 b	Exoclock	2022-03-31 20:33	2022-04-01 01:52
HAT-P-13 b	ETD	2022-04-03 18:38	2022-04-03 23:51
KELT-6 b	ETD	2022-04-04 16:30	2022-04-05 00:01
HAT-P-44 b	Exoclock	2022-04-18 19:54*	2022-04-19 01:07

Table 4: Shortened form of the table above listing proposed observation windows that do not occur late at night. The same formatting applies as in table 3, with the addition that yellow colouration indicates an observation that contains sunrise in the pre-transit hour.

Week beginning	deadlines	Transits	Progress checkpoints
2022-02-07			Collect related scientific papers
2022-02-14			
2022-02-21		2 x HAT-P-13 b	Lit. review draft
2022-02-28	Lit. review	HAT-P-44 b	Poster draft
2022-03-07	Poster submission		start writing code
2022-03-14	Poster presentation	K2-19 b	
2022-03-21		K2-19 b	
2022-03-28		2 x HAT-P-13 b	Initial TTV search code complete
2022-04-04		KELT-6 b	
2022-04-11			
2022-04-18		HAT-P-44 b	
2022-04-25			Final itteration of TTV search code complete
2022-05-02			presentation draft
2022-05-09	Presentation submission		
2022-05-16	Deliver oral presentation		Final dissertation draft
2022-05-23	Dissertation submission		

Table 5: A rough approximation of the schedule required for this project

4 Timescale

The project will take place over the next three months, with a rough timeline given in table 5. Included are required deadline, any transits from table 4, and ideal progress to have made by the end of that week.