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Determining the rotational velocity of stars with exoplanets

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ABSTRACT

1. Introduction

2. Methodology

First, we were asked to collect the rotational velocity literature values of stars present in the SWEET-Cat catalogue. We searched in three different databases: NASA Exoplanet catalogue, Vizier and Simbad. I collected the values present in the NASA Exoplanet Catalogue when my colleague Bárbara Oliveira was responsible for the other catalogues. We created a document with the values encountered with the mean, median and the values presented in NASA Exoplanet Catalogue. We excluded the values that were obtained by simulations and values determined a long time ago. Bárbara treated that part. We did not find the values for all stars present in the SWEET-Cat catalogue. We had all the literature values of the stars analysed in this study.

The next step was correct the spectrum of the stars in radial velocities, because most of them were shifted. For this we calculated the radial velocity of each spectrum using the ARES [reference] code and I constructed a little code to correct them. This tool is available in the Git Hub repository created for this project.

Now with the spectrum's corrected, we were able to the next step of the project. We used MOOG code to determine the *vsini* of the stars. The code was adapted to run for several stars, instead of one at a time. For the code to run we needed several parameters of the star: effective temperature of the star and respective uncertain (*Teff* and *eTeff*), logarithm of acceleration of gravity at the surface (*logg*), metallicity and respective uncertain (*[Fe/H]* and *e[Fe/H]*) and turbulence velocity (*vtur*). All of this parameter's values were present in the SWEET-Cat catalogue. The values of turbulence velocity that were in fault in the catalogue we assume the value of 1 for the program to run. There was another parameter needed to run the code: the limb darkening coefficient.

The limb darkening coefficient for each star was determined by a module in Python called Exoctk. In this module we need an effective temperature, the logarithm of the acceleration of gravity in the surface of the star, its metallicity and choose a model grid to calculate the linear coefficient. We choose the Kurucz ATLAS9 model grid. What we did was construct a grid of effective temperatures, *logg* acceleration and metallicity ranging between $[3500, 7000]K$, $[3.0, 5.0]$ dex and $[-0.5, 0.5]$ dex and obtain the linear limb darkening coefficient for each value of the grid and save in a document. With these values I adapted the main code to do a interpolation for the given parameters of a star and give a value for the limb darkening coefficient.

So, with a file containing all the parameters needed for the code to run, we can calculate the *vsini* for several stars at a time, and the program gives the rotational velocity and respective uncertain and the macro turbulence velocity. The program was constructed to save the parameters and results of each star in a file. We can encounter the adapted code of MOOG in a Git Hub repository [reference].

3. Results and Discussion

The results of the collected literature values for the stars present in the SWEET-Cat catalogue can be seen in the Git Hub repository. For comparison

4. Conclusions

References

Appendix A: Values of the parameters of the stars and simulated *vsini*

Star name	Spectograph	Inst_broad	Teff	eTeff	logg	[Fe/H]	e[Fe/H]	vtur	vsini	evsini	vmac
38Vir	HARPS	0.055	6440.0	51	4.42	0.16	0.05	1.44	27.738	3.288351	5.674
CoRoT-19	HARPS	0.055	6317.0	55	4.38	0.17	0.04	1.61	6.519	0.894457	5.171
CoRoT-2	HARPS	0.055	5676.0	44	4.71	0.01	0.03	1.77	10.262	0.345938	2.455
GJ3021	HARPS	0.055	5563.0	33	4.48	0.06	0.13	0.02	4.198	0.780407	2.723
HAT-P-46	HARPS	0.055	6344.0	27	4.43	0.36	0.02	1.47	4.665	0.391649	5.194
HATS-27	HARPS	0.055	6650.0	69	4.46	0.36	0.05	1.87	8.553	1.152382	5.500
HATS-56	HARPS	0.055	6594.0	63	3.98	0.25	0.04	1.75	6.799	0.790661	5.500
HATS-58A	HARPS	0.055	6564.0	41	4.35	0.13	0.03	1.65	4.887	0.683856	5.500
HD103774A	HARPS	0.055	6586.0	35	4.48	0.31	0.02	1.72	9.029	0.450904	5.500
HD10647	HARPS	0.055	6178.0	20	4.49	-0.01	0.01	1.26	5.226	0.335835	4.366
HD11231	HARPS	0.055	6643.0	35	4.32	0.19	0.02	1.96	7.465	0.456838	5.500
HD147873	HARPS	0.055	6180.0	27	4.06	0.26	0.02	1.65	9.006	0.446044	5.234
HD1666	HARPS	0.055	6508.0	30	4.29	0.39	0.02	1.77	6.192	0.270514	5.500
HD19994A	HARPS	0.055	6249.0	27	4.26	0.27	0.02	1.57	8.465	0.321891	5.115
HD205739	HARPS	0.055	6273.0	22	4.37	0.19	0.02	1.42	4.108	0.422668	4.998
HD208487	HARPS	0.055	6137.0	18	4.46	0.09	0.01	1.21	4.099	0.387713	4.268
HD50499	HARPS	0.055	6066.0	23	4.27	0.33	0.02	1.31	3.838	0.521332	4.390
HD60532	HARPS	0.055	6281.0	34	4.00	-0.07	0.02	1.80	6.655	0.628524	5.772
HR858	HARPS	0.055	6360.0	26	4.50	-0.02	0.02	1.51	7.921	0.377833	5.128
K2-100	HARPS	0.055	6377.0	65	4.81	0.32	0.05	2.05	13.441	1.058835	4.588
K2-290	HARPS	0.055	6385.0	23	4.44	0.04	0.02	1.58	6.738	0.418087	5.366
KELT-6	HARPS	0.055	6325.0	26	4.30	-0.23	0.02	1.65	4.196	0.694087	5.367
Pr0211	HARPS	0.055	5250.0	38	4.37	0.16	0.02	1.27	5.407	0.253316	2.678
TOI-813	HARPS	0.055	6187.0	34	4.26	0.22	0.03	1.62	8.100	0.445658	4.862
WASP-139	HARPS	0.055	5215.0	38	4.35	0.12	0.03	0.82	1.488	0.692144	2.712
WASP-166	HARPS	0.055	6142.0	22	4.45	0.25	0.02	1.25	4.868	0.418092	4.307
WASP-174	HARPS	0.055	6755.0	68	4.83	0.30	0.04	2.09	17.461	1.455187	5.500
WASP-190	HARPS	0.055	6730.0	55	4.52	0.15	0.04	2.07	14.151	0.878900	5.500
WASP-20	HARPS	0.055	6032.0	16	4.43	0.09	0.01	1.24	4.197	0.094191	3.954
WASP-31	HARPS	0.055	6380.0	36	4.59	-0.08	0.03	1.58	7.965	0.654885	5.042
WASP-84	HARPS	0.055	5232.0	41	4.30	0.05	0.03	1.03	3.082	0.066030	2.814
CoRoT-11	HARPS	0.055	6343.0	72	4.27	0.04	0.03	1.00	45.653	4.290752	5.509
CoRoT-3	HARPS	0.055	6558.0	44	4.25	0.14	0.04	1.00	17.979	1.143983	5.500
K2-232	HARPS	0.055	5961.0	18	4.33	0.07	0.01	1.19	2.797	0.155428	3.926
KOI-1257	HARPS	0.055	5528.0	54	4.10	0.22	0.04	1.01	3.734	0.441681	3.434
KELT-22A	HARPS	0.055	5803.0	26	4.45	0.21	0.02	1.29	6.978	0.309493	3.252
HD13908	ESPADONS	0.097	6241.0	24	4.16	0.00	0.02	1.52	3.289	0.676176	5.282
Kepler-65	ESPADONS	0.097	6374.0	37	4.41	0.23	0.03	1.54	8.700	0.641503	5.374
DSTucA	FEROS	0.130	5909.0	102	4.83	0.01	0.07	2.52	17.698	1.891794	2.772
HATS-10	FEROS	0.130	6167.0	82	4.51	0.40	0.06	1.45	5.753	2.101858	4.283
HATS-3	FEROS	0.130	6347.0	70	4.52	-0.02	0.05	1.41	8.097	1.541794	5.028
HATS-68	FEROS	0.130	6276.0	91	4.33	0.24	0.07	1.91	7.185	1.939750	5.091
HD70573	FEROS	0.130	5904.0	46	4.48	0.00	0.04	1.72	14.050	0.807978	3.458
TOI-677	FEROS	0.130	6300.0	53	4.52	0.14	0.04	1.35	6.850	1.012805	4.816
WASP-103	FIES	0.082	6188.0	75	4.48	0.29	0.06	1.69	10.820	1.142799	4.425
Kepler-21	NARVAL	0.110	6323.0	43	4.21	0.05	0.03	1.45	7.192	0.493763	5.538
Kepler-410A	NARVAL	0.110	6440.0	73	4.57	0.11	0.05	1.87	13.266	1.466446	5.374
HD115954	SOPHIE	0.072	5957.0	26	4.15	0.34	0.02	1.15	4.997	0.373632	4.274
HD27969	SOPHIE	0.072	5966.0	21	4.12	0.18	0.02	1.17	3.594	0.406969	4.362
HD93963A	SOPHIE	0.072	5987.0	64	4.49	0.10	0.04	1.15	6.194	0.728984	3.688
HAT-P-66	SOPHIE_HE	0.135	6250.0	43	4.29	0.15	0.03	1.20	5.000	4.000703	5.060
KPS-1	SOPHIE_HE	0.135	4963.0	222	4.17	0.22	0.14	0.24	6.518	1.179058	2.000
Kepler-40	SOPHIE_HE	0.135	6296.0	104	4.48	0.01	0.07	1.04	8.685	1.935214	4.878
Kepler-41	SOPHIE_HE	0.135	5766.0	118	4.32	0.21	0.09	0.47	5.384	1.086588	3.425
Kepler-435	SOPHIE_HE	0.135	6388.0	45	4.23	0.06	0.03	1.47	6.344	0.953887	5.800
Kepler-539	SOPHIE_HE	0.135	5841.0	44	4.52	-0.02	0.03	0.81	5.310	0.856838	3.207
Kepler-74	SOPHIE_HE	0.135	6056.0	62	4.41	0.34	0.05	1.23	5.432	1.007522	4.076
Kepler-89	SOPHIE_HE	0.135	6306.0	46	4.44	0.10	0.03	1.33	7.967	0.886533	5.002

WASP-113	SOPHIE_HE	0.135	6049.0	39	4.26	0.26	0.03	1.21	6.164	0.602682	4.352
WASP-135	SOPHIE_HE	0.135	5052.0	77	4.11	0.17	0.05	0.85	3.720	0.815719	3.232
WASP-150	SOPHIE_HE	0.135	6486.0	48	4.46	0.27	0.03	1.61	8.867	0.745661	5.827
WASP-153	SOPHIE_HE	0.135	5968.0	50	4.28	0.33	0.04	1.16	4.621	0.881658	4.048
WASP-92	SOPHIE_HE	0.135	6039.0	67	4.21	0.10	0.05	0.95	7.328	1.347581	4.418
HD12484	SOPHIE_HR	0.072	5915.0	30	4.54	0.09	0.02	1.19	8.715	0.266254	3.370
HD143105	SOPHIE_HR	0.072	6381.0	37	4.41	0.17	0.03	1.53	9.756	0.567290	5.407
HD196885A	SOPHIE_HR	0.072	6312.0	26	4.43	0.25	0.02	1.42	7.387	0.423998	5.049
HD63433	SOPHIE_HR	0.072	5671.0	26	4.49	0.00	0.02	1.11	7.051	0.222578	2.885
XO-7	SOPHIE_HR	0.072	6109.0	39	4.30	0.40	0.03	1.22	5.973	0.563651	4.484
TOI-1298	SOPHIE_HR	0.072	5889.0	43	4.39	0.19	0.03	1.17	2.338	0.563145	3.596
HD5278	ESPRESSO	0.045	6203.0	64	4.50	-0.12	0.04	1.31	3.958	1.145156	4.446
KOI-351	SOPHIE_HE	0.135	6142.0	65	4.47	0.15	0.05	0.94	5.584	1.217159	4.267
HAT-P-34	FEROS	0.130	6509.0	51	4.24	0.08	0.05	1.00	20.031	1.553165	5.500
Kepler-39	SOPHIE_HE	0.135	6556.0	85	4.78	0.06	0.06	1.55	14.379	2.166404	5.500
CoRoT-1	UVES	0.061	6344.0	74	4.46	0.12	0.05	1.24	6.175	1.389799	5.134
CoRoT-25	UVES	0.130	6104.0	29	4.30	0.16	0.02	1.21	2.813	0.766118	4.466
CoRoT-4	UVES	0.110	6238.0	37	4.55	0.18	0.03	1.23	6.866	0.698595	4.489
CoRoT-6	UVES	0.061	6265.0	40	4.60	0.01	0.03	1.31	9.133	0.712691	4.503
HAT-P-39	UVES	0.061	6721.0	98	4.79	0.22	0.06	2.04	13.468	1.815969	5.500
HAT-P-45	UVES	0.061	6531.0	55	4.65	0.14	0.04	1.60	9.609	0.746796	5.500
HAT-P-50	UVES	0.061	6377.0	47	4.30	-0.05	0.03	1.50	7.690	0.479211	5.608
HD106315	UVES	0.061	6591.0	87	4.75	-0.06	0.05	1.97	13.365	1.255221	5.500
HD133131B	UVES	0.087	5751.0	26	4.37	-0.28	0.02	0.90	1.000	0.000000	3.291
HD87646A	UVES	0.061	5949.0	38	4.28	0.28	0.03	1.43	8.226	0.513377	3.990
KELT-16	UVES	0.061	6514.0	54	4.45	0.09	0.04	1.46	5.658	0.829039	5.500
KELT-4A	UVES	0.061	6478.0	34	4.34	0.00	0.02	1.67	5.835	0.272670	6.026
WASP-118	UVES	0.061	6662.0	68	4.38	0.29	0.05	1.76	11.196	1.074250	5.500
WASP-120	UVES	0.061	6774.0	119	4.62	0.15	0.07	2.68	15.420	2.896492	5.500
WASP-136	UVES	0.061	6770.0	60	4.57	0.18	0.04	2.21	13.765	1.162951	5.500
WASP-138	UVES	0.061	6277.0	38	4.36	0.00	0.03	1.36	8.140	0.640882	5.035
WASP-75	UVES	0.061	6102.0	27	4.37	0.24	0.02	1.21	4.695	0.283019	4.319
WASP-87A	UVES	0.061	6529.0	89	4.51	-0.28	0.06	2.10	10.442	2.138976	5.500
WASP-90	UVES	0.061	6381.0	43	4.31	0.19	0.03	1.49	6.495	0.785650	5.607

Table A.1. Parameters ajhdushajd auhdsuhswaiqjd jahduhwidjew jahdiuweiqd-jwiebn jadijuqwjd ihajsd8yhewuwd juhduqwhqed dwbujehdwu