

Refined physical properties of the HAT-P-13 planetary system

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ABSTRACT

We present photometry of four transits of the planetary system HAT-P-13, obtained using defocussed telescopes. We analyse these, plus nine datasets from the literature, in order to determine the physical properties of the system. The mass and radius of the star are $M_A = 1.320 \pm 0.048 \pm 0.039 M_\odot$ and $R_A = 1.756 \pm 0.043 \pm 0.017 R_\odot$ (statistical and systematic errorbars). We find the equivalent quantities for the transiting planet to be $M_b = 0.906 \pm 0.024 \pm 0.018 M_{\text{Jup}}$ and $R_b = 1.487 \pm 0.038 \pm 0.015 R_{\text{Jup}}$, with an equilibrium temperature of $T'_{\text{eq}} = 1725 \pm 31$ K. Compared to previous results, which were based on much sparser photometric data, we find the star to be more massive and evolved, and the planet to be larger, hotter and more rarefied. The properties of the planet are not matched by standard models of irradiated gas giants. Its large radius anomaly is in line with the observation that the hottest planets are the most inflated, but at odds with the suggestion of inverse proportionality to the $\left[\frac{\text{Fe}}{\text{H}}\right]$ of the parent star. We assemble all available times of transit mid-point and determine a new linear ephemeris. Previous findings of transit timing variations in the HAT-P-13 system are shown to disagree with these measurements, and can be attributed to small-number statistics.

Key words: stars: planetary systems — stars: fundamental parameters — stars: individual: HAT-P-13

APPENDIX A: FULL RESULTS FOR THE LIGHT CURVES ANALYSED IN THIS WORK

The tables in this Appendix contain the detailed results of the analysis for HAT-P-13 studied in this work.

Note that whilst all the results are best fits to the relevant data, some parameters are unphysical (for example the limb darkening coefficients imply that the limb of the star produces a negative amount of light). In these cases the unphysical results have *not* been used but are retained in the tables for completeness.

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Table A1. Parameters of the JKTEBOP best fits of the i -band light curve from the Cassini Telescope (Loiano), using different approaches to LD. For each part of the table the upper quantities are fitted parameters and the lower quantities are derived parameters. T_0 is given as BJD(TDB) – 2455000.0. The light curve contains 274 datapoints.

	Linear LD law	Quadratic LD law	Square-root LD law	Logarithmic LD law	Cubic LD law
All LD coefficients fixed					
$r_A + r_B$	0.2120 ± 0.0069	0.2130 ± 0.0070	0.2140 ± 0.0067	0.2139 ± 0.0067	0.2205 ± 0.0061
k	0.09408 ± 0.00107	0.09297 ± 0.00099	0.09332 ± 0.00097	0.09310 ± 0.00103	0.09310 ± 0.00083
i (deg.)	81.43 ± 0.47	81.38 ± 0.47	81.28 ± 0.45	81.30 ± 0.46	80.73 ± 0.40
u_A	0.56 fixed	0.30 fixed	0.14 fixed	0.64 fixed	0.30 fixed
v_A		0.31 fixed	0.56 fixed	0.27 fixed	0.10 fixed
P	2.916123 ± 0.000028	2.916124 ± 0.000026	2.916124 ± 0.000028	2.916123 ± 0.000027	2.916123 ± 0.000027
T_0	599.39458 ± 0.00044	599.39458 ± 0.00045	599.39457 ± 0.00045	599.39458 ± 0.00046	599.39463 ± 0.00043
r_A	0.1938 ± 0.0062	0.1949 ± 0.0063	0.1957 ± 0.0060	0.1956 ± 0.0060	0.2017 ± 0.0055
r_B	0.01823 ± 0.00072	0.01812 ± 0.00075	0.01826 ± 0.00072	0.01821 ± 0.00072	0.01878 ± 0.00061
σ (mmag)	0.9260	0.9265	0.9279	0.9276	0.9356
χ^2_{red}	1.1523	1.1538	1.1562	1.1557	1.1753
Fitting for the linear LD coefficient and perturbing the nonlinear LD coefficient					
$r_A + r_B$	0.2109 ± 0.0087	0.2112 ± 0.0095	0.2103 ± 0.0089	0.2106 ± 0.0091	0.2108 ± 0.0086
k	0.0941 ± 0.0012	0.0929 ± 0.0012	0.0933 ± 0.0011	0.0931 ± 0.0012	0.0936 ± 0.0012
i (deg.)	81.53 ± 0.64	81.54 ± 0.70	81.61 ± 0.67	81.60 ± 0.68	81.56 ± 0.64
u_A	0.59 ± 0.09	0.35 ± 0.11	0.23 ± 0.11	0.72 ± 0.11	0.54 ± 0.10
v_A		0.31 perturbed	0.56 perturbed	0.27 perturbed	0.10 perturbed
P	2.916123 ± 0.000029	2.916124 ± 0.000026	2.916124 ± 0.000027	2.916124 ± 0.000028	2.916124 ± 0.000028
T_0	599.39459 ± 0.00047	599.39459 ± 0.00047	599.39459 ± 0.00046	599.39459 ± 0.00048	599.39459 ± 0.00044
r_A	0.1928 ± 0.0078	0.1932 ± 0.0084	0.1924 ± 0.0080	0.1926 ± 0.0081	0.1928 ± 0.0077
r_B	0.01815 ± 0.00091	0.01795 ± 0.00099	0.01795 ± 0.00091	0.01793 ± 0.00095	0.01805 ± 0.00092
σ (mmag)	0.9253	0.9260	0.9259	0.9260	0.9257
χ^2_{red}	1.1559	1.1578	1.1576	1.1579	1.1569
Fitting for both LD coefficients					
$r_A + r_B$	0.211 ± 0.008	0.245 ± 0.011	0.215 ± 0.012	0.215 ± 0.013	0.213 ± 0.013
k	0.0941 ± 0.0011	0.0803 ± 0.0028	0.0892 ± 0.0039	0.0874 ± 0.0038	0.0875 ± 0.0041
i (deg.)	81.53 ± 0.61	80.03 ± 0.77	81.63 ± 0.79	81.76 ± 0.82	81.89 ± 0.87
u_A	0.59 ± 0.09	-5.35 ± 5.40	-2.15 ± 2.39	1.89 ± 0.92	0.08 ± 0.53
v_A		8.5 ± 6.7	4.4 ± 3.8	2.2 ± 1.7	1.5 ± 1.1
P	2.916123 ± 0.000028	2.916133 ± 0.000029	2.916124 ± 0.000027	2.916128 ± 0.000028	2.916128 ± 0.000028
T_0	599.39459 ± 0.00047	599.39446 ± 0.00044	599.39461 ± 0.00047	599.39459 ± 0.00046	599.39459 ± 0.00045
r_A	0.193 ± 0.007	0.227 ± 0.011	0.197 ± 0.012	0.197 ± 0.013	0.196 ± 0.013
r_B	0.01815 ± 0.00084	0.01821 ± 0.00067	0.01758 ± 0.00111	0.01725 ± 0.00099	0.01714 ± 0.00110
σ (mmag)	0.9253	0.9219	0.9267	0.9275	0.9276
χ^2_{red}	1.1559	1.1597	1.1652	1.1666	1.1670

Table A2. Parameters of the JKTEBOP best fits of the HAT-P-13 *i*-band light curve from Bakos et al. (2009), using different approaches to LD. For each part of the table the upper quantities are fitted parameters and the lower quantities are derived parameters. The light curve contains 466 phase-binned datapoints.

	Linear LD law	Quadratic LD law	Square-root LD law	Logarithmic LD law	Cubic LD law
All LD coefficients fixed					
$r_A + r_b$	0.1878 ± 0.0079	0.1859 ± 0.0076	0.1904 ± 0.0073	0.1886 ± 0.0069	0.1967 ± 0.0063
k	0.08623 ± 0.00098	0.08511 ± 0.00093	0.08593 ± 0.00086	0.08556 ± 0.00083	0.08628 ± 0.00061
i (deg.)	83.08 ± 0.59	83.23 ± 0.58	82.87 ± 0.54	83.01 ± 0.51	82.29 ± 0.45
u_A	0.56 fixed	0.30 fixed	0.14 fixed	0.64 fixed	0.30 fixed
v_A		0.31 fixed	0.56 fixed	0.27 fixed	0.10 fixed
T_0	0.00005 ± 0.00010	0.00005 ± 0.00010	0.00005 ± 0.00010	0.00005 ± 0.00011	0.00004 ± 0.00011
r_A	0.1729 ± 0.0071	0.1713 ± 0.0069	0.1753 ± 0.0066	0.1737 ± 0.0063	0.1811 ± 0.0057
r_b	0.01491 ± 0.00077	0.01458 ± 0.00073	0.01506 ± 0.00070	0.01486 ± 0.00066	0.01562 ± 0.00058
σ (mmag)	0.8195	0.8175	0.8164	0.8165	0.8153
χ^2_{red}	1.0105	1.0053	1.0025	1.0027	0.9993
Fitting for the linear LD coefficient and perturbing the nonlinear LD coefficient					
$r_A + r_b$	0.1919 ± 0.0070	0.1930 ± 0.0079	0.1925 ± 0.0077	0.1928 ± 0.0081	0.1928 ± 0.0080
k	0.08649 ± 0.00077	0.08567 ± 0.00073	0.08601 ± 0.00070	0.08584 ± 0.00071	0.08619 ± 0.00076
i (deg.)	82.66 ± 0.53	82.60 ± 0.59	82.64 ± 0.59	82.61 ± 0.63	82.61 ± 0.60
u_A	0.423 ± 0.074	0.164 ± 0.100	0.048 ± 0.093	0.539 ± 0.093	0.361 ± 0.088
v_A		0.31 perturbed	0.56 perturbed	0.27 perturbed	0.10 perturbed
T_0	0.000040 ± 0.000100	0.000041 ± 0.000099	0.000041 ± 0.000107	0.000041 ± 0.000102	0.000042 ± 0.000108
r_A	0.1766 ± 0.0063	0.1777 ± 0.0071	0.1773 ± 0.0070	0.1776 ± 0.0074	0.1775 ± 0.0073
r_b	0.01527 ± 0.00065	0.01523 ± 0.00070	0.01525 ± 0.00069	0.01524 ± 0.00072	0.01530 ± 0.00071
σ (mmag)	0.8152	0.8146	0.8148	0.8147	0.8148
χ^2_{red}	1.0013	0.9997	1.0003	0.9999	1.0004
Fitting for both LD coefficients					
$r_A + r_b$	0.192 ± 0.007	0.210 ± 0.013	0.209 ± 0.011	0.203 ± 0.013	0.207 ± 0.014
k	0.0865 ± 0.0007	0.0745 ± 0.0030	0.0791 ± 0.0016	0.0784 ± 0.0021	0.0783 ± 0.0028
i (deg.)	82.66 ± 0.56	81.95 ± 0.93	81.99 ± 0.79	82.52 ± 0.83	82.26 ± 0.92
u_A	0.42 ± 0.07	-7.03 ± 6.39	-6.79 ± 2.80	2.81 ± 0.97	-0.93 ± 0.89
v_A		10.2 ± 7.9	11.3 ± 4.1	4.2 ± 2.1	3.3 ± 1.7
T_0	0.000040 ± 0.000105	0.000045 ± 0.000102	0.000045 ± 0.000101	0.000045 ± 0.000098	0.000046 ± 0.000107
r_A	0.177 ± 0.007	0.196 ± 0.013	0.194 ± 0.011	0.188 ± 0.012	0.192 ± 0.013
r_b	0.01527 ± 0.00067	0.01459 ± 0.00057	0.01533 ± 0.00070	0.01472 ± 0.00073	0.01500 ± 0.00073
σ (mmag)	0.8152	0.8136	0.8120	0.8124	0.8126
χ^2_{red}	1.0013	0.9983	0.9949	0.9957	0.9963

Table A3. Parameters of the JKTEBOP best fits of the *V*-band light curve of HAT-P-13 from Szabó et al. (2010), using different approaches to LD. For each part of the table the upper quantities are fitted parameters and the lower quantities are derived parameters. T_0 is given as BJD(UTC) – 2455000.0. The light curve contains 76 datapoints.

	Linear LD law	Quadratic LD law	Square-root LD law	Logarithmic LD law	Cubic LD law
All LD coefficients fixed					
$r_A + r_B$	0.194 ± 0.025	0.193 ± 0.025	0.194 ± 0.027	0.192 ± 0.024	0.213 ± 0.019
k	0.0840 ± 0.0040	0.0834 ± 0.0036	0.0836 ± 0.0039	0.0835 ± 0.0035	0.0863 ± 0.0023
i (deg.)	83.8 ± 2.3	83.8 ± 2.4	83.8 ± 2.6	83.8 ± 2.2	82.0 ± 1.4
u_A	0.68 fixed	0.53 fixed	0.37 fixed	0.75 fixed	0.40 fixed
v_A		0.21 fixed	0.47 fixed	0.24 fixed	0.10 fixed
T_0	141.55455 ± 0.00077	141.55453 ± 0.00076	141.55455 ± 0.00075	141.55459 ± 0.00072	141.55436 ± 0.00076
r_A	0.179 ± 0.022	0.179 ± 0.023	0.179 ± 0.025	0.178 ± 0.021	0.196 ± 0.017
r_B	0.0150 ± 0.0025	0.0149 ± 0.0026	0.0150 ± 0.0027	0.0148 ± 0.0024	0.0169 ± 0.0018
σ (mmag)	0.9677	0.9663	0.9662	0.9649	0.9767
χ^2_{red}	1.0933	1.0901	1.0899	1.0871	1.1139
Fitting for the linear LD coefficient and perturbing the nonlinear LD coefficient					
$r_A + r_B$	0.191 ± 0.024	0.192 ± 0.025	0.192 ± 0.024	0.193 ± 0.026	0.192 ± 0.026
k	0.0839 ± 0.0036	0.0835 ± 0.0036	0.0837 ± 0.0037	0.0836 ± 0.0039	0.0838 ± 0.0037
i (deg.)	83.9 ± 2.4	83.9 ± 2.6	83.8 ± 2.2	83.8 ± 2.8	83.9 ± 2.6
u_A	0.62 ± 0.13	0.47 ± 0.15	0.32 ± 0.13	0.75 ± 0.15	0.58 ± 0.14
v_A		0.21 perturbed	0.47 perturbed	0.24 perturbed	0.10 perturbed
T_0	141.55464 ± 0.00077	141.55459 ± 0.00078	141.55460 ± 0.00074	141.55458 ± 0.00077	141.55461 ± 0.00072
r_A	0.176 ± 0.021	0.177 ± 0.023	0.178 ± 0.021	0.178 ± 0.024	0.177 ± 0.023
r_B	0.0148 ± 0.0024	0.0148 ± 0.0025	0.0149 ± 0.0024	0.0149 ± 0.0027	0.0148 ± 0.0026
σ (mmag)	0.9657	0.9648	0.9651	0.9649	0.9651
χ^2_{red}	1.1043	1.1024	1.1031	1.1026	1.1031

Table A4. Parameters of the JKTEBOP best fits of the *R*-band light curve of HAT-P-13 from Szabó et al. (2010), using different approaches to LD. For each part of the table the upper quantities are fitted parameters and the lower quantities are derived parameters. T_0 is given as BJD(UTC) – 2455000.0. The light curve contains 140 datapoints.

	Linear LD law	Quadratic LD law	Square-root LD law	Logarithmic LD law	Cubic LD law
All LD coefficients fixed					
$r_A + r_B$	0.192 ± 0.022	0.187 ± 0.022	0.191 ± 0.021	0.191 ± 0.020	0.192 ± 0.018
k	0.0873 ± 0.0034	0.0857 ± 0.0030	0.0867 ± 0.0028	0.0865 ± 0.0026	0.0869 ± 0.0022
i (deg.)	83.1 ± 1.8	83.5 ± 1.8	83.1 ± 1.7	83.2 ± 1.5	82.9 ± 1.4
u_A	0.60 fixed	0.41 fixed	0.21 fixed	0.69 fixed	0.40 fixed
v_A		0.28 fixed	0.54 fixed	0.24 fixed	0.10 fixed
T_0	141.55017 ± 0.00082	141.55014 ± 0.00078	141.55012 ± 0.00083	141.55013 ± 0.00076	141.55001 ± 0.00079
r_A	0.176 ± 0.020	0.172 ± 0.020	0.176 ± 0.019	0.176 ± 0.018	0.177 ± 0.017
r_B	0.0154 ± 0.0023	0.0147 ± 0.0021	0.0153 ± 0.0021	0.0152 ± 0.0019	0.0154 ± 0.0018
σ (mmag)	1.3203	1.3212	1.3164	1.3172	1.3108
χ^2_{red}	1.1333	1.1348	1.1266	1.1279	1.1170
Fitting for the linear LD coefficient and perturbing the nonlinear LD coefficient					
$r_A + r_B$	0.204 ± 0.018	0.208 ± 0.020	0.207 ± 0.019	0.207 ± 0.018	0.206 ± 0.019
k	0.0876 ± 0.0019	0.0869 ± 0.0022	0.0872 ± 0.0022	0.0871 ± 0.0020	0.0874 ± 0.0020
i (deg.)	81.9 ± 1.3	81.7 ± 1.5	81.7 ± 1.4	81.7 ± 1.3	81.8 ± 1.3
u_A	0.26 ± 0.24	0.01 ± 0.28	-0.11 ± 0.29	0.35 ± 0.29	0.19 ± 0.28
v_A		0.28 perturbed	0.54 perturbed	0.24 perturbed	0.10 perturbed
T_0	141.54991 ± 0.00079	141.54996 ± 0.00080	141.54996 ± 0.00078	141.54996 ± 0.00079	141.54994 ± 0.00074
r_A	0.187 ± 0.017	0.191 ± 0.019	0.190 ± 0.018	0.190 ± 0.016	0.190 ± 0.017
r_B	0.0164 ± 0.0015	0.0166 ± 0.0016	0.0166 ± 0.0016	0.0166 ± 0.0014	0.0166 ± 0.0015
σ (mmag)	1.3077	1.3089	1.3086	1.3088	1.3084
χ^2_{red}	1.1199	1.1221	1.1216	1.1219	1.1212

Table A5. Parameters of the JKTEBOP best fits of the HAT-P-13 *R*-band light curve from Pál et al. (2011), using different approaches to LD. For each part of the table the upper quantities are fitted parameters and the lower quantities are derived parameters. T_0 is given as BJD(UTC) – 2455000.0. The light curve contains 1040 datapoints.

	Linear LD law	Quadratic LD law	Square-root LD law	Logarithmic LD law	Cubic LD law
All LD coefficients fixed					
$r_A + r_b$	0.2499 ± 0.0107	0.2449 ± 0.0113	0.2505 ± 0.0103	0.2491 ± 0.0102	0.2551 ± 0.0097
k	0.0946 ± 0.0015	0.0930 ± 0.0017	0.0935 ± 0.0014	0.0932 ± 0.0015	0.0929 ± 0.0012
i (deg.)	78.92 ± 0.64	79.31 ± 0.71	78.89 ± 0.65	78.99 ± 0.65	78.50 ± 0.59
u_A	0.60 fixed	0.41 fixed	0.21 fixed	0.69 fixed	0.40 fixed
v_A		0.28 fixed	0.54 fixed	0.24 fixed	0.10 fixed
T_0	590.64442 ± 0.00080	590.64453 ± 0.00079	590.64445 ± 0.00079	590.64451 ± 0.00080	590.64434 ± 0.00075
r_A	0.2283 ± 0.0095	0.2241 ± 0.0101	0.2291 ± 0.0092	0.2278 ± 0.0091	0.2334 ± 0.0086
r_b	0.02160 ± 0.00118	0.02083 ± 0.00124	0.02141 ± 0.00110	0.02124 ± 0.00114	0.02167 ± 0.00097
σ (mmag)	2.2650	2.2663	2.2648	2.2652	2.2621
χ^2_{red}	1.0056	1.0064	1.0055	1.0058	1.0040
Fitting for the linear LD coefficient and perturbing the nonlinear LD coefficient					
$r_A + r_b$	0.216 ± 0.019	0.217 ± 0.020	0.217 ± 0.018	0.217 ± 0.019	0.217 ± 0.020
k	0.0903 ± 0.0038	0.0891 ± 0.0040	0.0896 ± 0.0037	0.0894 ± 0.0036	0.0899 ± 0.0037
i (deg.)	81.5 ± 1.6	81.5 ± 1.6	81.4 ± 1.5	81.5 ± 1.5	81.4 ± 1.6
u_A	0.83 ± 0.13	0.63 ± 0.19	0.49 ± 0.17	0.95 ± 0.18	0.78 ± 0.16
v_A		0.28 perturbed	0.54 perturbed	0.24 perturbed	0.10 perturbed
T_0	590.64475 ± 0.00074	590.64473 ± 0.00078	590.64473 ± 0.00080	590.64473 ± 0.00077	590.64474 ± 0.00079
r_A	0.198 ± 0.017	0.199 ± 0.018	0.199 ± 0.016	0.199 ± 0.017	0.199 ± 0.017
r_b	0.0179 ± 0.0023	0.0177 ± 0.0023	0.0178 ± 0.0021	0.0178 ± 0.0022	0.0179 ± 0.0022
σ (mmag)	2.2655	2.2648	2.2651	2.2650	2.2652
χ^2_{red}	1.0064	1.0061	1.0062	1.0062	1.0062
Fitting for both LD coefficients					
$r_A + r_b$	0.216 ± 0.017	0.251 ± 0.021	0.249 ± 0.020	0.249 ± 0.020	0.250 ± 0.022
k	0.0903 ± 0.0035	0.0809 ± 0.0035	0.0849 ± 0.0026	0.0837 ± 0.0027	0.0837 ± 0.0032
i (deg.)	81.5 ± 1.3	79.8 ± 1.4	79.9 ± 1.3	80.0 ± 1.3	79.9 ± 1.4
u_A	0.83 ± 0.13	-2.03 ± 2.86	-3.04 ± 2.44	2.43 ± 0.57	0.09 ± 0.92
v_A		4.3 ± 3.7	6.3 ± 3.6	2.7 ± 1.3	2.0 ± 1.5
T_0	590.64475 ± 0.00078	590.64491 ± 0.00078	590.64496 ± 0.00073	590.64493 ± 0.00076	590.64494 ± 0.00073
r_A	0.198 ± 0.015	0.232 ± 0.020	0.230 ± 0.019	0.229 ± 0.018	0.231 ± 0.021
r_b	0.0179 ± 0.0020	0.0188 ± 0.0015	0.0195 ± 0.0016	0.0192 ± 0.0016	0.0193 ± 0.0016
σ (mmag)	2.2655	2.2618	2.2628	2.2623	2.2624
χ^2_{red}	1.0064	1.0029	1.0028	1.0028	1.0030

Table A6. Parameters of the JKTEBOP best fits of the HAT-P-13 *I*-band light curve from Pál et al. (2011), using different approaches to LD. For each part of the table the upper quantities are fitted parameters and the lower quantities are derived parameters. T_0 is given as BJD(UTC) – 2455000.0. The light curve contains 460 datapoints.

	Linear LD law	Quadratic LD law	Square-root LD law	Logarithmic LD law	Cubic LD law
All LD coefficients fixed					
$r_A + r_B$	0.202 ± 0.016	0.201 ± 0.017	0.203 ± 0.016	0.203 ± 0.016	0.226 ± 0.014
k	0.0889 ± 0.0022	0.0878 ± 0.0023	0.0883 ± 0.0021	0.0881 ± 0.0020	0.0899 ± 0.0016
i (deg.)	82.11 ± 1.15	82.32 ± 1.28	82.07 ± 1.16	82.12 ± 1.15	80.43 ± 0.90
u_A	0.49 fixed	0.31 fixed	0.11 fixed	0.61 fixed	0.30 fixed
v_A		0.31 fixed	0.56 fixed	0.26 fixed	0.10 fixed
T_0	558.56265 ± 0.00071	558.56261 ± 0.00068	558.56264 ± 0.00069	558.56263 ± 0.00071	558.56244 ± 0.00075
r_A	0.186 ± 0.015	0.184 ± 0.016	0.187 ± 0.015	0.186 ± 0.015	0.207 ± 0.012
r_B	0.0165 ± 0.0017	0.0162 ± 0.0017	0.0165 ± 0.0017	0.0164 ± 0.0016	0.0186 ± 0.0013
σ (mmag)	2.2403	2.2388	2.2402	2.2398	2.2433
χ^2_{red}	0.9994	0.9980	0.9993	0.9990	1.0020
Fitting for the linear LD coefficient and perturbing the nonlinear LD coefficient					
$r_A + r_B$	0.197 ± 0.020	0.197 ± 0.023	0.197 ± 0.022	0.197 ± 0.023	0.197 ± 0.021
k	0.0885 ± 0.0027	0.0874 ± 0.0031	0.0879 ± 0.0028	0.0876 ± 0.0031	0.0881 ± 0.0030
i (deg.)	82.6 ± 1.5	82.7 ± 1.9	82.6 ± 1.7	82.7 ± 1.8	82.6 ± 1.6
u_A	0.61 ± 0.17	0.38 ± 0.21	0.25 ± 0.19	0.74 ± 0.18	0.56 ± 0.17
v_A		0.31 perturbed	0.56 perturbed	0.26 perturbed	0.10 perturbed
T_0	558.56262 ± 0.00072	558.56263 ± 0.00071	558.56263 ± 0.00073	558.56263 ± 0.00073	558.56263 ± 0.00070
r_A	0.181 ± 0.018	0.181 ± 0.021	0.181 ± 0.020	0.181 ± 0.020	0.181 ± 0.019
r_B	0.0161 ± 0.0020	0.0158 ± 0.0023	0.0159 ± 0.0022	0.0159 ± 0.0022	0.0160 ± 0.0021
σ (mmag)	2.2388	2.2385	2.2386	2.2385	2.2386
χ^2_{red}	1.0002	0.9999	1.0000	1.0000	1.0001
Fitting for both LD coefficients					
$r_A + r_B$	0.197 ± 0.021	0.197 ± 0.025	0.200 ± 0.025	0.195 ± 0.023	0.195 ± 0.024
k	0.0885 ± 0.0029	0.0819 ± 0.0074	0.0849 ± 0.0063	0.0832 ± 0.0067	0.0831 ± 0.0075
i (deg.)	82.6 ± 1.6	83.1 ± 2.0	82.7 ± 1.8	83.2 ± 1.7	83.2 ± 1.9
u_A	0.61 ± 0.16	-0.71 ± 2.03	-1.62 ± 3.36	1.60 ± 1.28	0.24 ± 0.77
v_A		2.1 ± 2.7	3.6 ± 5.2	1.6 ± 2.1	1.2 ± 1.6
T_0	558.56262 ± 0.00070	558.56243 ± 0.00070	558.56257 ± 0.00072	558.56248 ± 0.00074	558.56247 ± 0.00074
r_A	0.181 ± 0.019	0.182 ± 0.024	0.184 ± 0.023	0.180 ± 0.021	0.180 ± 0.022
r_B	0.0161 ± 0.0021	0.0149 ± 0.0023	0.0156 ± 0.0024	0.0150 ± 0.0022	0.0150 ± 0.0024
σ (mmag)	2.2388	2.2380	2.2382	2.2381	2.2381
χ^2_{red}	1.0002	1.0017	1.0019	1.0018	1.0018

Table A7. Parameters of the JKTEBOP best fits of the R -band light curve of HAT-P-13 from Nascimbeni et al. (2011), using different approaches to LD. For each part of the table the upper quantities are fitted parameters and the lower quantities are derived parameters. The light curve contains 504 phase-binned datapoints.

	Linear LD law	Quadratic LD law	Square-root LD law	Logarithmic LD law	Cubic LD law
All LD coefficients fixed					
$r_A + r_b$	0.1941 ± 0.0042	0.1894 ± 0.0045	0.1935 ± 0.0040	0.1926 ± 0.0043	0.1971 ± 0.0037
k	0.08724 ± 0.00056	0.08571 ± 0.00063	0.08657 ± 0.00053	0.08632 ± 0.00052	0.08693 ± 0.00040
i (deg.)	82.65 ± 0.30	83.05 ± 0.34	82.69 ± 0.30	82.77 ± 0.31	82.32 ± 0.27
u_A	0.60 fixed	0.41 fixed	0.21 fixed	0.69 fixed	0.40 fixed
v_A		0.28 fixed	0.54 fixed	0.24 fixed	0.10 fixed
T_0	-0.000384 ± 0.000059	-0.000383 ± 0.000054	-0.000381 ± 0.000056	-0.000381 ± 0.000055	-0.000378 ± 0.000056
r_A	0.1785 ± 0.0038	0.1745 ± 0.0041	0.1781 ± 0.0036	0.1773 ± 0.0039	0.1813 ± 0.0034
r_b	0.01557 ± 0.00041	0.01496 ± 0.00045	0.01542 ± 0.00039	0.01530 ± 0.00040	0.01577 ± 0.00034
σ (mmag)	0.5526	0.5545	0.5456	0.5470	0.5361
χ^2_{red}	1.1513	1.1589	1.1204	1.1263	1.0799
Fitting for the linear LD coefficient and perturbing the nonlinear LD coefficient					
$r_A + r_b$	0.2013 ± 0.0038	0.2013 ± 0.0042	0.2013 ± 0.0040	0.2012 ± 0.0042	0.2011 ± 0.0039
k	0.08732 ± 0.00037	0.08645 ± 0.00039	0.08677 ± 0.00038	0.08663 ± 0.00041	0.08692 ± 0.00046
i (deg.)	81.95 ± 0.28	81.97 ± 0.32	81.97 ± 0.30	81.98 ± 0.31	81.97 ± 0.29
u_A	0.363 ± 0.042	0.124 ± 0.070	-0.001 ± 0.061	0.464 ± 0.055	0.304 ± 0.057
v_A		0.28 perturbed	0.54 perturbed	0.24 perturbed	0.10 perturbed
T_0	-0.000378 ± 0.000054	-0.000378 ± 0.000055	-0.000378 ± 0.000057	-0.000378 ± 0.000055	-0.000378 ± 0.000056
r_A	0.1852 ± 0.0035	0.1853 ± 0.0038	0.1852 ± 0.0037	0.1852 ± 0.0038	0.1851 ± 0.0035
r_b	0.01617 ± 0.00034	0.01602 ± 0.00036	0.01607 ± 0.00036	0.01604 ± 0.00036	0.01609 ± 0.00035
σ (mmag)	0.5339	0.5336	0.5336	0.5336	0.5337
χ^2_{red}	1.0728	1.0716	1.0715	1.0715	1.0719
Fitting for both LD coefficients					
$r_A + r_b$	0.2013 ± 0.0039	0.2188 ± 0.0079	0.2195 ± 0.0074	0.2104 ± 0.0081	0.2262 ± 0.0078
k	0.0873 ± 0.0004	0.0741 ± 0.0019	0.0790 ± 0.0011	0.0790 ± 0.0019	0.0763 ± 0.0017
i (deg.)	81.95 ± 0.28	81.37 ± 0.54	81.28 ± 0.47	81.84 ± 0.49	80.93 ± 0.54
u_A	0.36 ± 0.04	-9.24 ± 6.01	-8.07 ± 1.95	2.78 ± 0.80	-2.18 ± 1.10
v_A		12.8 ± 7.3	13.1 ± 2.8	4.7 ± 1.7	5.3 ± 1.7
T_0	-0.000378 ± 0.000055	-0.000381 ± 0.000056	-0.000379 ± 0.000056	-0.000380 ± 0.000058	-0.000385 ± 0.000059
r_A	0.1852 ± 0.0035	0.2037 ± 0.0077	0.2034 ± 0.0071	0.1950 ± 0.0079	0.2102 ± 0.0076
r_b	0.01617 ± 0.00034	0.01509 ± 0.00029	0.01606 ± 0.00038	0.01540 ± 0.00039	0.01604 ± 0.00030
σ (mmag)	0.5339	0.5365	0.5326	0.5346	0.5338
χ^2_{red}	1.0728	1.0873	1.0708	1.0788	1.0761

Table A8. Parameters of the JKTEBOP best fits of the FTN *Z*-band light curve from Fulton et al. (2011), using different approaches to LD. For each part of the table the upper quantities are fitted parameters and the lower quantities are derived parameters. T_0 is given as BJD(TDB) – 2455000.0. The light curve contains 897 datapoints.

	Linear LD law	Quadratic LD law	Square-root LD law	Logarithmic LD law	Cubic LD law
All LD coefficients fixed					
$r_A + r_b$	0.231 ± 0.013	0.234 ± 0.013	0.233 ± 0.013	0.236 ± 0.013	0.245 ± 0.010
k	0.0889 ± 0.0019	0.0880 ± 0.0020	0.0879 ± 0.0018	0.0881 ± 0.0019	0.0873 ± 0.0016
i (deg.)	80.14 ± 0.85	79.92 ± 0.87	80.01 ± 0.84	79.83 ± 0.86	79.06 ± 0.66
u_A	0.50 fixed	0.23 fixed	0.07 fixed	0.59 fixed	0.20 fixed
v_A		0.32 fixed	0.57 fixed	0.28 fixed	0.10 fixed
T_0	231.94124 ± 0.00086	231.94117 ± 0.00091	231.94126 ± 0.00089	231.94117 ± 0.00092	231.94112 ± 0.00088
r_A	0.2119 ± 0.0118	0.2154 ± 0.0121	0.2138 ± 0.0115	0.2165 ± 0.0120	0.2255 ± 0.0095
r_b	0.0188 ± 0.0013	0.0189 ± 0.0014	0.0188 ± 0.0013	0.0191 ± 0.0014	0.0197 ± 0.0010
σ (mmag)	2.7090	2.7085	2.7092	2.7087	2.7106
χ^2_{red}	0.9990	0.9987	0.9990	0.9988	1.0000
Fitting for the linear LD coefficient and perturbing the nonlinear LD coefficient					
$r_A + r_b$	0.228 ± 0.017	0.230 ± 0.019	0.229 ± 0.018	0.230 ± 0.018	0.234 ± 0.017
k	0.0891 ± 0.0025	0.0878 ± 0.0026	0.0884 ± 0.0026	0.0880 ± 0.0027	0.0888 ± 0.0030
i (deg.)	80.3 ± 1.2	80.3 ± 1.3	80.3 ± 1.3	80.3 ± 1.3	80.0 ± 1.2
u_A	0.56 ± 0.20	0.27 ± 0.28	0.17 ± 0.25	0.66 ± 0.25	0.46 ± 0.26
v_A		0.32 perturbed	0.57 perturbed	0.28 perturbed	0.10 perturbed
T_0	231.94124 ± 0.00084	231.94125 ± 0.00088	231.94122 ± 0.00084	231.94125 ± 0.00089	231.94116 ± 0.00090
r_A	0.210 ± 0.015	0.211 ± 0.017	0.211 ± 0.016	0.211 ± 0.016	0.215 ± 0.016
r_b	0.0187 ± 0.0016	0.0185 ± 0.0016	0.0186 ± 0.0016	0.0186 ± 0.0016	0.0191 ± 0.0015
σ (mmag)	2.7087	2.7086	2.7086	2.7086	2.7086
χ^2_{red}	1.0001	1.0000	1.0000	1.0000	0.9999
Fitting for both LD coefficients					
$r_A + r_b$	0.228 ± 0.018	0.240 ± 0.019	0.244 ± 0.018	0.243 ± 0.022	0.244 ± 0.022
k	0.0891 ± 0.0026	0.0762 ± 0.0039	0.0789 ± 0.0034	0.0785 ± 0.0057	0.0781 ± 0.0053
i (deg.)	80.3 ± 1.3	80.1 ± 1.3	79.6 ± 1.3	79.8 ± 1.5	79.7 ± 1.4
u_A	0.6 ± 0.2	-5.1 ± 4.2	-7.6 ± 4.5	2.9 ± 1.7	-1.5 ± 2.0
v_A		7.5 ± 4.7	12.2 ± 6.2	4.9 ± 5.1	3.8 ± 3.2
T_0	231.94124 ± 0.00093	231.94129 ± 0.00087	231.94141 ± 0.00088	231.94134 ± 0.00092	231.94133 ± 0.00086
r_A	0.210 ± 0.017	0.223 ± 0.018	0.226 ± 0.017	0.225 ± 0.021	0.227 ± 0.021
r_b	0.0187 ± 0.0016	0.0170 ± 0.0015	0.0179 ± 0.0013	0.0176 ± 0.0015	0.0177 ± 0.0015
σ (mmag)	2.7087	2.7084	2.7081	2.7080	2.7081
χ^2_{red}	1.0001	1.0008	1.0003	1.0004	1.0005

Table A9. Parameters of the JKTEBOP best fits of the FLWO i -band light curve from Fulton et al. (2011), using different approaches to LD. For each part of the table the upper quantities are fitted parameters and the lower quantities are derived parameters. T_0 is given as BJD(TDB) – 2455000.0. The light curve contains 456 datapoints.

	Linear LD law	Quadratic LD law	Square-root LD law	Logarithmic LD law	Cubic LD law
All LD coefficients fixed					
$r_A + r_b$	0.212 ± 0.014	0.203 ± 0.014	0.208 ± 0.014	0.205 ± 0.014	0.214 ± 0.012
k	0.0885 ± 0.0020	0.0863 ± 0.0018	0.0871 ± 0.0018	0.0866 ± 0.0018	0.0870 ± 0.0014
i (deg.)	81.28 ± 0.93	81.92 ± 0.97	81.53 ± 0.94	81.71 ± 0.99	81.00 ± 0.79
u_A	0.56 fixed	0.30 fixed	0.14 fixed	0.64 fixed	0.30 fixed
v_A		0.31 fixed	0.56 fixed	0.27 fixed	0.10 fixed
T_0	511.90906 ± 0.00059	511.90896 ± 0.00061	511.90898 ± 0.00064	511.90895 ± 0.00063	511.90897 ± 0.00057
r_A	0.195 ± 0.012	0.187 ± 0.012	0.191 ± 0.013	0.189 ± 0.013	0.197 ± 0.011
r_b	0.0172 ± 0.0014	0.0161 ± 0.0014	0.0167 ± 0.0014	0.0164 ± 0.0014	0.0171 ± 0.0011
σ (mmag)	1.8489	1.8478	1.8452	1.8456	1.8366
χ^2_{red}	1.0222	1.0209	1.0181	1.0186	1.0087
Fitting for the linear LD coefficient and perturbing the nonlinear LD coefficient					
$r_A + r_b$	0.223 ± 0.015	0.225 ± 0.014	0.223 ± 0.014	0.223 ± 0.015	0.224 ± 0.015
k	0.0826 ± 0.0037	0.0815 ± 0.0037	0.0820 ± 0.0037	0.0818 ± 0.0039	0.0821 ± 0.0041
i (deg.)	80.2 ± 1.0	80.0 ± 1.0	80.1 ± 1.0	80.1 ± 1.1	80.1 ± 1.1
u_A	-0.31 ± 0.66	-0.70 ± 0.74	-0.75 ± 0.66	-0.28 ± 0.75	-0.43 ± 0.77
v_A		0.31 perturbed	0.56 perturbed	0.27 perturbed	0.10 perturbed
T_0	511.90887 ± 0.00058	511.90887 ± 0.00061	511.90887 ± 0.00059	511.90886 ± 0.00057	511.90888 ± 0.00061
r_A	0.206 ± 0.014	0.208 ± 0.014	0.206 ± 0.014	0.206 ± 0.015	0.207 ± 0.014
r_b	0.01699 ± 0.00077	0.01693 ± 0.00074	0.01692 ± 0.00076	0.01689 ± 0.00077	0.01699 ± 0.00075
σ (mmag)	1.8243	1.8245	1.8244	1.8244	1.8244
χ^2_{red}	0.9977	0.9978	0.9977	0.9978	0.9977
Fitting for both LD coefficients					
$r_A + r_b$	0.223 ± 0.014	0.231 ± 0.017	0.231 ± 0.018	0.214 ± 0.012	0.226 ± 0.016
k	0.0826 ± 0.0039	0.0753 ± 0.0070	0.0770 ± 0.0085	0.0899 ± 0.0122	0.0801 ± 0.0107
i (deg.)	80.19 ± 1.01	79.55 ± 1.24	79.59 ± 1.29	80.74 ± 0.87	79.97 ± 1.12
u_A	-0.31 ± 0.67	-5.18 ± 5.80	-5.41 ± 7.79	-0.42 ± 0.36	-0.97 ± 3.19
v_A		3.8 ± 5.2	6.2 ± 10.6	-1.4 ± 2.0	0.6 ± 3.3
T_0	511.90887 ± 0.00058	511.90885 ± 0.00057	511.90888 ± 0.00059	511.90887 ± 0.00057	511.90886 ± 0.00059
r_A	0.206 ± 0.014	0.215 ± 0.017	0.215 ± 0.018	0.197 ± 0.013	0.209 ± 0.017
r_b	0.0170 ± 0.0008	0.0162 ± 0.0012	0.0165 ± 0.0012	0.0177 ± 0.0016	0.0167 ± 0.0015
σ (mmag)	1.8243	1.8250	1.8251	1.8238	1.8246
χ^2_{red}	0.9977	1.0006	1.0007	0.9993	1.0002

Table A10. Parameters of the JKTEBOP best fits of the Sedgwick *i*-band light curve from Fulton et al. (2011), using different approaches to LD. For each part of the table the upper quantities are fitted parameters and the lower quantities are derived parameters. T_0 is given as BJD(TDB) – 2455000.0. The light curve contains 332 datapoints.

	Linear LD law	Quadratic LD law	Square-root LD law	Logarithmic LD law	Cubic LD law
All LD coefficients fixed					
$r_A + r_b$	0.198 ± 0.011	0.199 ± 0.011	0.200 ± 0.012	0.200 ± 0.011	0.204 ± 0.010
k	0.0879 ± 0.0016	0.0870 ± 0.0015	0.0873 ± 0.0015	0.0871 ± 0.0015	0.0872 ± 0.0012
i (deg.)	82.39 ± 0.84	82.30 ± 0.82	82.24 ± 0.84	82.25 ± 0.80	81.81 ± 0.70
u_A	0.56 fixed	0.30 fixed	0.14 fixed	0.64 fixed	0.30 fixed
v_A		0.31 fixed	0.56 fixed	0.27 fixed	0.10 fixed
T_0	619.80769 ± 0.00052	619.80770 ± 0.00054	619.80769 ± 0.00050	619.80769 ± 0.00052	619.80768 ± 0.00051
r_A	0.1819 ± 0.0103	0.1834 ± 0.0102	0.1838 ± 0.0107	0.1837 ± 0.0102	0.1878 ± 0.0092
r_b	0.01599 ± 0.00116	0.01596 ± 0.00112	0.01605 ± 0.00116	0.01601 ± 0.00111	0.01637 ± 0.00094
σ (mmag)	1.3140	1.3153	1.3160	1.3160	1.3225
χ^2_{red}	1.0366	1.0382	1.0389	1.0389	1.0480
Fitting for the linear LD coefficient and perturbing the nonlinear LD coefficient					
$r_A + r_b$	0.198 ± 0.015	0.199 ± 0.015	0.198 ± 0.015	0.198 ± 0.014	0.198 ± 0.014
k	0.0880 ± 0.0020	0.0871 ± 0.0019	0.0874 ± 0.0020	0.0872 ± 0.0020	0.0876 ± 0.0019
i (deg.)	82.4 ± 1.1	82.4 ± 1.2	82.4 ± 1.2	82.4 ± 1.1	82.4 ± 1.1
u_A	0.59 ± 0.12	0.35 ± 0.16	0.23 ± 0.14	0.72 ± 0.15	0.53 ± 0.14
v_A		0.31 perturbed	0.56 perturbed	0.27 perturbed	0.10 perturbed
T_0	619.80769 ± 0.00054	619.80771 ± 0.00056	619.80771 ± 0.00054	619.80771 ± 0.00054	619.80770 ± 0.00054
r_A	0.182 ± 0.013	0.183 ± 0.014	0.182 ± 0.014	0.182 ± 0.013	0.182 ± 0.013
r_b	0.0160 ± 0.0015	0.0160 ± 0.0015	0.0159 ± 0.0015	0.0159 ± 0.0015	0.0160 ± 0.0014
σ (mmag)	1.3137	1.3148	1.3143	1.3146	1.3142
χ^2_{red}	1.0395	1.0410	1.0404	1.0407	1.0402
Fitting for both LD coefficients					
$r_A + r_b$	0.1976 ± 0.0140	0.1918 ± 0.0084	0.1915 ± 0.0082	0.1920 ± 0.0088	0.1922 ± 0.0083
k	0.0880 ± 0.0018	0.0939 ± 0.0059	0.0925 ± 0.0044	0.0932 ± 0.0049	0.0931 ± 0.0051
i (deg.)	82.44 ± 1.06	82.69 ± 0.63	82.65 ± 0.61	82.64 ± 0.62	82.62 ± 0.62
u_A	0.59 ± 0.12	1.71 ± 0.65	3.05 ± 1.38	-0.05 ± 0.33	1.18 ± 0.37
v_A		-1.40 ± 0.77	-3.71 ± 2.05	-1.42 ± 0.79	-1.06 ± 0.59
T_0	619.80769 ± 0.00052	619.80760 ± 0.00050	619.80759 ± 0.00052	619.80759 ± 0.00052	619.80759 ± 0.00052
r_A	0.1816 ± 0.0127	0.1753 ± 0.0074	0.1753 ± 0.0074	0.1756 ± 0.0080	0.1759 ± 0.0072
r_b	0.0160 ± 0.0014	0.0165 ± 0.0014	0.0162 ± 0.0011	0.0164 ± 0.0012	0.0164 ± 0.0013
σ (mmag)	1.3137	1.3086	1.3084	1.3084	1.3085
χ^2_{red}	1.0395	1.0366	1.0362	1.0363	1.0363

Table A11. Sets of derived physical properties of the HAT-P-13 system. For each set of physical properties the following quantities are the same: $g_b = 10.15 \pm 0.43 \text{ m s}^{-2}$, $\rho_A = 0.2437 \pm 0.0134 \rho_\odot$ and $T'_{\text{eq}} = 1725 \pm 31 \text{ K}$.

	(dEB constraint)	(Claret models)	(Y ² models)	(Teramo models)	(VRSS models)	(DSEP models)
K_b (km s ⁻¹)	167.75 ± 4.12	161.37 ± 0.27	161.38 ± 1.95	163.37 ± 0.57	161.39 ± 0.50	161.41 ± 0.83
M_A (M _⊙)	1.471 ± 0.108	1.310 ± 0.061	1.310 ± 0.048	1.359 ± 0.014	1.310 ± 0.012	1.311 ± 0.022
R_A (R _⊙)	1.821 ± 0.058	1.752 ± 0.033	1.752 ± 0.043	1.773 ± 0.036	1.752 ± 0.034	1.752 ± 0.011
$\log g_A$ (cgs)	4.085 ± 0.0182	4.069 ± 0.016	4.069 ± 0.017	4.074 ± 0.015	4.069 ± 0.016	4.069 ± 0.020
M_b (M _{Jup})	0.974 ± 0.068	0.901 ± 0.021	0.902 ± 0.024	0.924 ± 0.009	0.902 ± 0.009	0.902 ± 0.010
R_b (R _{Jup})	1.542 ± 0.050	1.484 ± 0.031	1.484 ± 0.038	1.502 ± 0.032	1.484 ± 0.032	1.484 ± 0.009
ρ_b (ρ _{Jup})	0.2482 ± 0.017	0.258 ± 0.016	0.258 ± 0.017	0.255 ± 0.016	0.258 ± 0.016	0.258 ± 0.002
Θ	0.0390 ± 0.0013	0.0405 ± 0.0009	0.0405 ± 0.0011	0.0400 ± 0.0009	0.0405 ± 0.0009	0.0405 ± 0.0023
a (AU)	0.04544 ± 0.00111	0.04372 ± 0.00007	0.04372 ± 0.00053	0.04426 ± 0.00015	0.04372 ± 0.00013	0.04372 ± 0.00023
Age (Gyr)		$3.7^{+0.0}_{-0.0}$	$3.8^{+0.0}_{-0.8}$	$2.8^{+0.0}_{-0.0}$	$3.4^{+0.0}_{-0.0}$	$3.8^{+1.1}_{-2.9}$