Asteroseismology of Close Binary Stars: Tides and Mass Transfer

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ABSTRACT

Please see the following table, which contains the stellar/orbital and pulsational parameters of 22 heartbeat binaries.

REFERENCES

Guo, Z. 2021, Frontiers in Astronomy and Space Sciences

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Table 1. Heartbeat Binaries with TEOs (A-, F-type)

| Name        | $T_{\text{eff}}$ | logg | $M_1$, $M_2$, $P_{\text{orb}}$, $f_{\text{orb}}$ (d, d$^{-1}$) | $i$, $e$, $\omega$ | $\text{TEO}(N=f/f_{\text{orb}})$ | $\text{TEO}, A/10^{-3}$ | $\text{TEO}, \phi/(2\pi)$ | remark |
|-------------|------------------|------|----------------------------------------------------------|-----------------|-------------------------------|--------------------------|--------------------------|--------|
| KIC9016693  | 26.3680271       | 25.6 | 24                                                       | 0.19238         | 0.275                         | m=0                     |                         |        |
| 7262 K, -   | 0.0379247        | 0.596|                                                           |                 |                               |                          |                         |        |
| ≈ 1.6, ≈ 1.6 $M_\odot$ |            |      |                                                          |                 |                               |                          |                         |        |
| KIC8719324  | 10.2326979       | 73.54 | 26                                                       | 0.64472         | 0.26                          | m=0                     |                         |        |
| 7750 K, 4.5 | 0.0977259        | 0.6  |                                                           | 0.0789          | 0.87                          | m=2                     |                         |        |
| -, -        |                 |      |                                                          |                 |                               |                          |                         |        |
| KIC4248941  | 8.6445976        | 68.3 | 5                                                        | 0.48790         | 0.545                         | m=2                     |                         |        |
| 6750 K, 4.5 | 0.1156792        | 0.423|                                                           |                 |                               |                          |                         |        |
| -, -        |                 |      |                                                          |                 |                               |                          |                         |        |
| KIC 5034333 | 6.9322800       | 49.88 | 18                                                       | 0.1760          | 0.58                          | m=                       |                         |        |
| 9250 K, 4.5 | 0.1442527        | 0.58 |                                                           | 0.1500          | 0.677                         | m=                       |                         |        |
| -, -        |                 |      |                                                          |                 |                               |                          |                         |        |
| KIC 5034333 | 6.9322800       | 49.88 | 18                                                       | 0.1760          | 0.58                          | m=                       |                         |        |
| 9250 K, 4.5 | 0.1442527        | 0.58 |                                                           | 0.1500          | 0.677                         | m=                       |                         |        |
| -, -        |                 |      |                                                          |                 |                               |                          |                         |        |
| HD209295    | 3.10575          | 40-45 | 8                                                        | 18.3, 13.2      | 0.185                         | m=                       |                         |        |
| 7750 K, 4.3 | 0.32198          | 0.352|                                                           | 8.4, 6.6        | 0.006                         | m=                       |                         |        |
| 1.84, 0.6-1 $M_\odot$ |     |      |                                                           | 7.0, 6.2        | 0.891                         | m=                       |                         |        |
|             |                 |      |                                                          | 4.6, 3.9        | 0.550                         | m=                       |                         |        |
|             |                 |      |                                                          | 4.5, 3.5        | 0.131                         | m=                       |                         |        |
| KIC 3749404 | 20.3063852      | 62   | 21                                                       | 0.0807          | 0.88                          | m=                       |                         |        |
| 8000/6000 K, 4.4/4.1 | 0.04924567 | 0.659|                                                           | 0.0670          | 0.93                          | m=                       |                         |        |
| 1.78, 1.32 $M_\odot$ |        |      |                                                           | 0.0491          | 0.87                          | m=                       |                         |        |
|             |                 |      |                                                          | 0.0266          | 0.92                          | m=                       |                         |        |
|             |                 |      |                                                          | 0.021           | 0.05                          | m=                       |                         |        |
|             |                 |      |                                                          | 0.0347          | 0.65                          | m=                       |                         |        |
|             |                 |      |                                                          | 0.0344          | 0.71                          | m=                       |                         |        |
|             |                 |      |                                                          | 0.0121          | 0.22                          | m=                       |                         |        |
|             |                 |      |                                                          | 0.0096          | 0.79                          | m=                       |                         |        |
|             |                 |      |                                                          | 0.0091          | 0.92                          | m=                       |                         |        |
| KIC 4142768 | 13.9958015      | 75.81 | 9                                                        | 0.995           | 0.0304                        | m=2                     |                         |        |
| 7327/7383 K, 3.81/3.95 | 0.071449999 | 0.582|                                                           | 1.129           | 0.8681                        | m=2                     |                         |        |
| 2.05, 2.05 $M_\odot$ |       |      |                                                          | 328.2           | 17                            | 0.325                   | 0.5515                   | m=2    |
| Name; $T_{\text{eff}}, \log g; M_{1,2}$, $P_{\text{orb}}$ & $f_{\text{orb}}$ (d, d$^{-1}$) | $i, \epsilon, \omega$ | TEO($N = f/f_{\text{orb}}$) | TEO, A/10$^{-3}$ | TEO,$\phi/(2\pi)$ | remark |
|----------------|----------------|----------------|----------------|----------------|----------------|
| 2.96, 2.51$R_\odot$ | 14 | 0.332 | 0.5757 | m=2 |
| | 13 | 0.304 | 0.5657 | m=2 |
| | 12 | 0.252 | 0.5796 | m=2 |
| | 10 | 0.251 | 0.0533 | m=2 |
| | 18 | 0.105 | 0.5394 | m=2 |
| | 20 | 0.096 | 0.5063 | m=2 |
| | 24 | 0.078 | 0.4800 | m=2 |
| **KIC 3230227** | 7.0471062 | 73.42$^\circ$ | 13.88 | 0.338 | 0.1647 | m= |
| 8000/8180 K, 4.10/4.23 | 0.141902 | 0.60 | 21 | 0.194 | 0.8681 | m=2 |
| 1.84, 1.73$M_\odot$ | 17 | 0.177 | 0.3867 | m= |
| | 19 | 0.154 | 0.3569 | m= |
| | 12.12 | 0.192 | 0.3419 | m= |
| | 18 | 0.124 | 0.8654 | m= |
| | 9.88 | 0.179 | 0.9722 | m= |
| | 20 | 0.073 | 0.3470 | m= |
| | 13 | 0.085 | 0.3183 | m= |
| | 22 | 0.043 | 0.3299 | m= |
| | 12 | 0.069 | 0.4935 | m= |
| | 24.12 | 0.033 | 0.3161 | m= |
| | 23 | 0.031 | 0.3312 | m= |
| | 26 | 0.024 | 0.3187 | m= |
| | 13 | 0.042 | 0.5133 | m= |
| | 31 | 0.016 | 0.0207 | m= |
| | 28 | 0.017 | 0.3246 | m= |
| | 16 | 0.027 | 0.4319 | m= |
| | 27 | 0.017 | 0.3228 | m= |
| | 10 | 0.036 | 0.5079 | m= |
| | 5 | 0.065 | 0.6236 | m= |
| | 14.13 | 0.025 | 0.2494 | m= |
| | 40 | 0.010 | 0.8318 | m= |
| | 30 | 0.009 | 0.4460 | m= |
| | 16.13 | 0.014 | 0.0677 | m= |
| | 11 | 0.018 | 0.8303 | m= |
| **KIC 11494130** | 18.9554 | 79.2$^\circ$ | 53 | 0.03 | - | m=0 |
| 6600 K, 4.2 | 0.052755 | 0.66 |
| 1.4, 0.5$M_\odot$ | 263$^\circ$ |
| Name | $T_{\text{eff}}$, logg | $P_{\text{orb}}$ & $f_{\text{orb}}$ (d, d$^{-1}$) | $i, e, \omega$ | TEO(N=f/$f_{\text{orb}}$) | TEO, A/10$^{-3}$ | TEO,$\phi/$(2$\pi$) | remark |
|------|---------------------|---------------------------------|---------------|-------------------------|-----------------|-----------------|--------|
| **KIC 5790807** | 79.996246 | 85.82$^\circ$ | 48 | 0.017 | 0.17 | - | m=2 |
| ≈ 6466 K, 3.42 | 0.01250 | 0.855 | 107 | 0.015 | - | 0.723 | m=2 |
| 1.74, 0.44$M_{\odot}$ | 155.6$^\circ$ | | | | | | |
| **KIC 8164262** | 87.45717 | 65$^\circ$ | 229 | 10.1 | 0.4526 | 0.855 | 107 | m=2 |
| 6890/3500 K, 3.9/- | 0.01143417 | 0.886 | 241 | 0.353 | - | - | m=2 |
| 1.70, 0.36$M_{\odot}$ | 84.79$^\circ$ | | | | | | |
| **KIC 4544587** | 2.189 094 | 87.9$^\circ$ | 4 | 0.593 | 0.17 | - | m=2 |
| 8600/7750 K, 4.24/4.33 | 0.456810 | 0.275 | 3 | 0.520 | 0.776 | - | m=2 |
| 1.98, 1.61$M_{\odot}$ | 328.9$^\circ$ | | | | | | |
| **KOI54=KIC8112039** | 41.8050 | 5.5$^\circ$ | | | | | |
| 8500/8800 K, 4.12/4.08 | 0.023921 | 0.8335 | 90 | 0.294 | 0.2865 | - | m=0 |
| 2.33, 2.39$M_{\odot}$ | 36.7$^\circ$ | | | | | | |
| **Only A ≥ 2$\mu$mag** | | | | | | | |


Table 1—Continued

| Name; $T_{\text{eff}}$, logg; $M_{1,2}$ , $P_{\text{orb}}$ & $f_{\text{orb}}$ (d, d$^{-1}$) | $i, e, \omega$ | TEO($N=f/f_{\text{orb}}$) | TEO, A/10$^{-3}$ | TEO,$\phi/(2\pi)$ | remark |
|---|---|---|---|---|---|
| 71 | 0.0110 | 0.2348 |
| 75 | 0.0104 | 0.0435 |
| 27 | 0.0084 | 0.0754 |
| 43 | 0.0085 | 0.9820 |
| 45 | 0.0088 | 0.0337 |
| 36 | 0.0063 | 0.3958 |
| 52 | 0.0071 | 0.6981 |
| 33 | 0.0057 | 0.2535 |
| 29 | 0.0044 | 0.8189 |
| 48 | 0.0059 | 0.5982 |
| 78 | 0.0051 | 0.5579 |
| 49 | 0.0051 | 0.1353 |
| 32 | 0.0047 | 0.9288 |
| 57 | 0.0045 | 0.3559 |
| 46 | 0.0043 | 0.5158 |
| 31 | 0.0042 | 0.3690 |
| 26 | 0.0041 | 0.8731 |
| 42 | 0.0040 | 0.0634 |
| 51 | 0.0040 | 0.1753 |
| 55 | 0.0036 | 0.2478 |
| 35 | 0.0034 | 0.3227 |
| 50 | 0.0034 | 0.6736 |
| 25 | 0.0030 | 0.2808 |
| 38 | 0.0029 | 0.3940 |
| 22 | 0.0028 | 0.7832 |
| 34 | 0.0026 | 0.7702 |
| 30 | 0.0025 | 0.9400 |
| 24 | 0.0025 | 0.7270 |
| 23 | 0.0021 | 0.4992 |
| 127 | 0.0021 | 0.9778 |
| 54 | 0.0020 | 0.6138 |
| aharmonic: | | | | | |
| 22.419 | 0.00787 | 0.5181 |
| 68.582 | 0.00490 | 0.1187 |
| 63.076 | 0.00246 | 0.7570 |
| 57.577 | 0.00157 | 0.5055 |
| 25.846 | 0.00112 | 0.1672 |
| Name; $T_{\text{eff}}$, logg; $M_{1,2}$, $P_{\text{orb}}$ & $f_{\text{orb}}$ (d, d$^{-1}$) | $i, e, \omega$ | TEO(N=$f/f_{\text{orb}}$) | TEO, $A/10^{-3}$ | TEO, $\phi/(2\pi)$ | remark |
|---|---|---|---|---|---|
| 35.844 | 0.00090 | 0.3692 | 60.419 | 0.00059 | 0.3859 |
| 42.106 | 0.00066 | 0.8551 | 59.969 | 0.00057 | 0.0866 |
| 41.417 | 0.00041 | 0.9145 | 49.589 | 0.00036 | 0.1480 |
| 25.076 | 0.00030 | 0.1305 | 24.844 | 0.00029 | 0.8995 |
| 44.078 | 0.00029 | 0.6138 | 93.197 | 0.00029 | 0.5309 |
| 80.087 | 0.00021 | 0.5274 | 72.088 | 0.00020 | 0.8363 |
| 27.581 | 0.00020 | 0.0812 | - | - | - |
| **p Vel A** | 10.2437 | 32.72$^\circ$ | 5 | 0.1346 | - | m= |
| -/- K, -/- | 0.09762 | 0.3528 | 8 | 0.0458 | - | m= |
| **F5 IV, F1 V** | 169.4$^\circ$ | 11 | 0.0562 | - | m= |
| -/- K, -/- | 0.04076 | 0.707 | 4 | 0.1184 | - | m= |
| **A3-A8** | 119.96$^\circ$ | 7 | 0.1999 | - | m= |
| -/- K, -/- | 0.048697 | 0.621 | 5 | 0.0140 | - | m= |
| **A2,A2** | 114.5$^\circ$ | 6 | 0.0181 | - | m= |
| **ζ$^\dagger$ UMa** | 20.5351 | 44.66$^\circ$ | 3 | 0.0394 | - | m= |
| -/- K, -/- | 0.048697 | 0.621 | 5 | 0.0140 | - | m= |
| **A2,A2** | 114.5$^\circ$ | 6 | 0.0181 | - | m= |
| ≈ 2.2, 2.2$M_\odot$ | 8 | 0.0111 | - | m= |
| -/- K, -/- | 0.12170 | 0.3327 | 9 | 0.2078 | - | m= |
| **HD158013** | 8.21675 | 50.97$^\circ$ | 7 | 0.0468 | - | m= |
| -/- K, -/- | 0.12170 | 0.3327 | 9 | 0.2078 | - | m= |
| **Am** | 129.57$^\circ$ | 18 | 0.0229 | - | m= |
Table 1—Continued

| Name; $T_{\text{eff}}$, logg; $M_{1,2}$ , $P_{\text{orb}}$ & $f_{\text{orb}}$ (d, d$^{-1}$) | $i, e, \omega$ | TEO($N=f/f_{\text{orb}}$) | TEO, A/10$^{-3}$ | TEO,$\phi/(2\pi)$ | remark |
|---|---|---|---|---|---|
| 14 Peg | 5.30824 | 17.32$^{\circ}$ | 8 | 0.040 | - | m= |
| -/- K, -/- | 0.18839 | 0.5333 | 17 | 0.041 | - | m= |
| A1V,A1V | | 310.9$^{\circ}$ | | | | |

Table 2. Heartbeat Binaries with TEOs (O,B-type)

| Name; $T_{\text{eff}}$, logg; $M_{1,2}$ , $P_{\text{orb}}$ & $f_{\text{orb}}$ (d, d$^{-1}$) | $i, e, \omega$ | TEO($N=f/f_{\text{orb}}$) | TEO, A/10$^{-3}$ | TEO,$\phi/(2\pi)$ | remark |
|---|---|---|---|---|---|
| ι Ori | 29.13376 | 62.86$^{\circ}$ | Red/Blue | Red/Blue | m= |
| 31, 18.3 (10$^{3}$K), - | 0.034324 | 0.7452 | 23 | 0.92/0.97 | 0.734/0.382 | m= |
| 3.89, 4.18 | 122.15$^{\circ}$ | 25 | 0.44/- | 0.452/- | m= |
| 23.18, 13.94$M_{\odot}$ | 27 | 0.66/0.78 | 0.504/0.869 | m= |
| 9.10, 4.94$R_{\odot}$ | 33 | 0.58/0.7 | 0.211/0.09 | m= |
| MACHO | 32.83 | 44.9$^{\circ}$ | 8 | 3 | 0.010 | m= |
| 80.7443.1718 | 0.0305 | 0.565 | 10 | 6 | 0.177 | m= |
| ≈ 25(10$^{3}$K) | 61.1$^{\circ}$ | 17 | 9 | 0.078 | m= |
| ≈ 30$M_{\odot}$ | 25 | 14 | 0.395 | m= |
| QX Car | 4.47948 | 34.77$^{\circ}$ | 5 | 0.156 | - | m= |
| -/- K, -/- | 0.22324 | 0.2677 | 7 | 0.221 | - | m= |
| B2V, B2V | 174.7$^{\circ}$ | 10 | 0.131 | - | m= |
| 12 | 0.137 | - | m= |
| V1294 Sco | 5.6010 | 46.2$^{\circ}$ | 7 | 1.14 | - | m= |
| -/- K, -/- | 0.17854 | 0.2578 | - | m= |
| O9IV,O9.7V | 130.8$^{\circ}$ | 3 | 0.091 | 0.570 | m= |
| HD174884 | 3.65705 | 73.35$^{\circ}$ | 8 | 0.120 | 0.349 | m= |
| 13140/12044K | 0.27344 | 0.2939 | 13 | 0.111 | 0.822 | m= |
| 4.04,2.72$M_{\odot}$ | 51.31$^{\circ}$ | 3 | 0.091 | 0.570 | m= |
| 3.77,2.04$R_{\odot}$ | 4 | 0.097 | 0.840 | m= |