

# Phosphorus-rich stars with unusual abundances are challenging theoretical predictions

Thomas Masseron, D. A. García-Hernández, Raúl Santoveña Gómez, Arturo Manchado Torres, Olga Zamora, Minia Manteiga, Carlos Dafonte

June 18, 2020

Supplementary Table 1: Basic parameters of the P-rich stars

| star               | T <sub>eff</sub> | log g      | $\mu_t$ | [Fe/H]                                | SNR | dist. | Lum. | <rv>    | rms   | #visit | $\Delta t$ |
|--------------------|------------------|------------|---------|---------------------------------------|-----|-------|------|---------|-------|--------|------------|
| 2M00044180-0005553 | 4597( 33)        | 2.01(0.13) | 1.38    | -1.01 <sup>0.13</sup> <sub>0.00</sub> | 553 | 4300  | 276  | -59.67  | 0.08  | 10     | 300        |
| 2M12071315+1555010 | 5119( 29)        | 2.24(0.28) | 1.33    | -0.87 <sup>0.15</sup> <sub>0.01</sub> | 55  | 9700  | 264  | 28.49   | 0.05  | 3      | 411        |
| 2M13314691+2804210 | 4224(177)        | 1.22(0.52) | 1.66    | -1.02 <sup>0.14</sup> <sub>0.03</sub> | 249 | 9000  | 1120 | -1.80   | 0.03  | 4      | 8          |
| 2M13472354+2210562 | 5377(295)        | 2.2(1.56)  | 1.34    | -1.24 <sup>0.21</sup> <sub>0.17</sub> | 164 | 2200  | 60   | 30.75   | 0.47  | 3      | 3          |
| 2M13535604+4437076 | 5143( 97)        | 2.5(0.82)  | 1.30    | -0.89 <sup>0.19</sup> <sub>0.02</sub> | 346 | 1500  | 60   | -128.88 | 0.01  | 3      | 346        |
| 2M16092248+2449223 | 4208( 75)        | 1.07(0.1)  | 1.74    | -1.06 <sup>0.2</sup> <sub>0.04</sub>  | 363 | 9800  | 1561 | -92.42  | 0.29  | 5      | 15         |
| 2M16482145-1930487 | 4481( 57)        | 1.61(1.31) | 1.50    | -0.87 <sup>0.17</sup> <sub>0.03</sub> | 98  | 8000  | 330  | 65.93   | 0.04  | 3      | 706        |
| 2M17033361-2254246 | 4783( 84)        | 2.27(0.03) | 1.33    | -0.77 <sup>0.35</sup> <sub>0.02</sub> | 62  | 8700  | 49   | 81.50   | 1.76* | 15     | 388        |
| 2M17183459+4302520 | 5130( 1)         | 2.66(0.25) | 1.29    | -0.91 <sup>0.22</sup> <sub>0.00</sub> | 91  | 10900 | 92   | -135.80 | 0.27  | 15     | 371        |
| 2M17214096+4246147 | 4550( 67)        | 1.49(0.06) | 1.54    | -0.98 <sup>0.14</sup> <sub>0.02</sub> | 179 | 9800  | 883  | -297.56 | 0.07  | 5      | 31         |
| 2M17502038-2805411 | 3885( 46)        | 0.28(0.54) | 2.25    | -1.01 <sup>0.15</sup> <sub>0.12</sub> | 101 | 4300  | 249  | -52.73  | 0.13  | 2      | 11         |
| 2M18120031-1350169 | 4244(179)        | 1.36(0.1)  | 1.60    | -0.88 <sup>0.15</sup> <sub>0.07</sub> | 130 | 5000  | 200  | -36.24  | 0.00  | 1      | 0          |
| 2M19105369+2717150 | 5255( 31)        | 3.21(0.14) | 1.32    | -0.83 <sup>0.2</sup> <sub>0.03</sub>  | 73  | 4700  | 43   | -5.08   | 0.18  | 7      | 11         |
| 2M19214936-1232462 | 4096( 97)        | 1.09(0.46) | 1.73    | -0.91 <sup>0.14</sup> <sub>0.04</sub> | 266 | 12300 | 1277 | -146.57 | 0.23  | 3      | 222        |
| 2M19281906+4915086 | 4425(109)        | 1.63(0.15) | 1.49    | -1.15 <sup>0.13</sup> <sub>0.05</sub> | 374 | 4700  | 603  | -302.63 | 0.21  | 2      | 50         |

Effective temperatures (T<sub>eff</sub> in K) and surface gravities (log g) uncertainties are shown in parentheses.  $\mu_t$  are the microturbulence velocities (in km s<sup>-1</sup>) assumed for the abundances derivation. [Fe/H] represent the metallicities of the stars relative to the solar value based on Fe lines measurement. The upper indices show the random errors while the bottom indices show the systematic errors. dist are the distances of the stars in parsec. Lum. are the stars luminosities relative to the Solar one. < rv > show the average radial velocities, rms the dispersion around that value (both in km s<sup>-1</sup>) and #visit the number of observed spectra. and  $\Delta t$  (in days) the total observation period range.

\* star suspected to be a binary

Supplementary Table 2: Basic parameters of the P-normal stars

| star               | $T_{\text{eff}}$ | $\log g$   | $\mu_t$ | [Fe/H]                  | SNR  | dist. | Lum. | $\langle rv \rangle$ | rms  | #visit |
|--------------------|------------------|------------|---------|-------------------------|------|-------|------|----------------------|------|--------|
| 2M00022364+1558539 | 5229( 79)        | 2.4(0.88)  | 1.31    | $-0.77^{+0.13}_{-0.01}$ | 301  | 1900  | 57   | -60.30               | 0.05 | 3      |
| 2M01262518+1719099 | 5232(130)        | 2.39(1.03) | 1.31    | $-0.84^{+0.11}_{-0.01}$ | 724  | 1000  | 55   | 35.53                | 0.21 | 5      |
| 2M01271266+1801037 | 4730(216)        | 2.17(0.21) | 1.35    | $-1.13^{+0.13}_{-0.1}$  | 1405 | 700   | 96   | 101.02               | 0.53 | 5      |
| 2M02150319-0437411 | 5027(177)        | 2.9(0.08)  | 1.29    | $-0.97^{+0.16}_{-0.1}$  | 550  | 700   | 20   | 80.77                | 0.10 | 3      |
| 2M07404920+3621206 | 4610( 54)        | 2.26(0.28) | 1.33    | $-0.65^{+0.13}_{-0.00}$ | 358  | 2900  | 71   | 66.74                | 0.04 | 7      |
| 2M07461742+4828201 | 4709(182)        | 2.03(0.25) | 1.37    | $-1.05^{+0.24}_{-0.11}$ | 410  | 2400  | 194  | -39.46               | 0.07 | 2      |
| 2M11202609+0024314 | 4391( 94)        | 1.02(0.47) | 1.76    | $-1.1^{+0.15}_{-0.05}$  | 271  | 9800  | 846  | 195.36               | 0.30 | 3      |
| 2M13240275+2516183 | 5168(138)        | 2.29(0.99) | 1.33    | $-0.86^{+0.14}_{-0.04}$ | 305  | 1300  | 69   | 69.02                | 0.04 | 3      |
| 2M15563661+2716483 | 4533(165)        | 1.78(0.1)  | 1.44    | $-1.01^{+0.18}_{-0.02}$ | 327  | 2700  | 315  | 17.36                | 0.01 | 2      |
| 2M16164586+4652131 | 4668(113)        | 1.97(0.07) | 1.39    | $-1.01^{+0.14}_{-0.06}$ | 305  | 2500  | 140  | -112.77              | 0.04 | 3      |
| 2M16471103-0156177 | 4566(640)        | 1.74(1.26) | 1.45    | $-0.99^{+0.17}_{-0.29}$ | 264  | 8700  | 2441 | -44.43               | 0.00 | 1      |
| 2M17142525+4324562 | 4490(110)        | 1.7(0)     | 1.47    | $-1.04^{+0.14}_{-0.05}$ | 406  | 5700  | 341  | -106.93              | 0.04 | 5      |
| 2M19311218-0840354 | 4765( 27)        | 2.09(0.02) | 1.36    | $-0.65^{+0.14}_{-0.01}$ | 212  | 5200  | 211  | 18.51                | 0.28 | 3      |
| 2M19320870+4926497 | 4733(123)        | 2.4(0.21)  | 1.31    | $-0.74^{+0.09}_{-0.06}$ | 212  | 1600  | 54   | -80.09               | 0.00 | 1      |
| 2M21330531+0041464 | 4548( 42)        | 2.05(0.19) | 1.37    | $-0.82^{+0.13}_{-0.03}$ | 476  | 1900  | 120  | -96.13               | 0.12 | 6      |

Effective temperatures ( $T_{\text{eff}}$  in K) and surface gravities ( $\log g$ ) uncertainties are shown in parentheses.  $\mu_t$  are the microturbulence velocities (in  $\text{km s}^{-1}$ ) assumed for the abundances derivation. [Fe/H] represent the metallicities of the stars relative to the solar value based on Fe lines measurement. The upper indices show the random errors while the bottom indices show the systematic errors. dist are the distances of the stars in parsec. Lum. are the stars luminosities relative to the Solar one.  $\langle rv \rangle$  show the average radial velocities, rms the dispersion around that value (both in  $\text{km s}^{-1}$ ) and #visit the number of observed spectra.

Supplementary Table 3: Abundances of the P-rich stars

| star       | [C/Fe]                                | [N/Fe]                               | [O/Fe]                               | [Na/Fe]                              | [Mg/Fe]                               | [Al/Fe]                               | [Si/Fe]                              | [P/Fe]                                | [S/Fe]                               |
|------------|---------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|---------------------------------------|---------------------------------------|--------------------------------------|---------------------------------------|--------------------------------------|
| 2M00044180 | 0.24 <sup>0.05</sup> <sub>0.08</sub>  | 0.35 <sup>0.14</sup> <sub>0.09</sub> | 0.71 <sup>0.03</sup> <sub>0.07</sub> | <0.42 ...                            | 0.47 <sup>0.1</sup> <sub>0.04</sub>   | 0.7 <sup>0.02</sup> <sub>0.09</sub>   | 0.59 <sup>0.06</sup> <sub>0.02</sub> | 1.35 <sup>0.3</sup> <sub>0.09</sub>   | 0.32 <sup>0.04</sup> <sub>0.08</sub> |
| 2M12071315 | 0.06 <sup>0.06</sup> <sub>0.39</sub>  | <0.91 ...                            | <1.25 ...                            | <0.27 ...                            | 0.71 <sup>0.09</sup> <sub>0.09</sub>  | 1.3 <sup>0.1</sup> <sub>0.09</sub>    | 0.9 <sup>0.04</sup> <sub>0.1</sub>   | 1.2 <sup>0.16</sup> <sub>0.1</sub>    | 0.42 <sup>0.14</sup> <sub>0.11</sub> |
| 2M13314691 | -0.06 <sup>0.17</sup> <sub>0.16</sub> | 0.77 <sup>0.05</sup> <sub>0.19</sub> | 0.89 <sup>0.08</sup> <sub>0.29</sub> | <0.31 ...                            | 0.58 <sup>0.09</sup> <sub>0.05</sub>  | 1.11 <sup>0.01</sup> <sub>0.09</sub>  | 0.86 <sup>0.12</sup> <sub>0.16</sub> | 1.53 <sup>0.31</sup> <sub>0.1</sub>   | 0.43 <sup>0.12</sup> <sub>0.25</sub> |
| 2M13472354 | 0.33 <sup>0.04</sup> <sub>0.09</sub>  | <1.46 ...                            | ... ...                              | <0.71 ...                            | 0.59 <sup>0.11</sup> <sub>0.3</sub>   | 0.86 <sup>0.03</sup> <sub>0.09</sub>  | 0.87 <sup>0.12</sup> <sub>0.24</sub> | 1.65 <sup>0.26</sup> <sub>0.1</sub>   | 0.56 <sup>0.13</sup> <sub>0.1</sub>  |
| 2M13535604 | -0.06 <sup>0.02</sup> <sub>0.68</sub> | <0.77 ...                            | <1.56 ...                            | <0.28 ...                            | 0.91 <sup>0.1</sup> <sub>0.24</sub>   | 1.75 <sup>0.01</sup> <sub>0.09</sub>  | 1.39 <sup>0.13</sup> <sub>0.09</sub> | 2.1 <sup>0.25</sup> <sub>0.1</sub>    | 0.5 <sup>0.13</sup> <sub>0.09</sub>  |
| 2M16092248 | -0.05 <sup>0.11</sup> <sub>0.13</sub> | <0.83 ...                            | 1.17 <sup>0.06</sup> <sub>0.29</sub> | <0.35 ...                            | 0.68 <sup>0.1</sup> <sub>0.01</sub>   | 1.29 <sup>0</sup> <sub>0.1</sub>      | 1.02 <sup>0.13</sup> <sub>0.02</sub> | 1.81 <sup>0.21</sup> <sub>0.09</sub>  | 0.12 <sup>0.19</sup> <sub>0.2</sub>  |
| 2M16482145 | 0.11 <sup>0.14</sup> <sub>0.35</sub>  | <0.41 ...                            | 0.89 <sup>0.05</sup> <sub>0.11</sub> | <0.23 ...                            | 0.67 <sup>0.15</sup> <sub>0.04</sub>  | 1.19 <sup>0.07</sup> <sub>0.09</sub>  | 0.79 <sup>0.14</sup> <sub>0.16</sub> | 1.57 <sup>0.17</sup> <sub>0.1</sub>   | 0.41 <sup>0.21</sup> <sub>0.46</sub> |
| 2M17033361 | 0.06 <sup>0.08</sup> <sub>0.12</sub>  | 0.41 <sup>0.2</sup> <sub>0.09</sub>  | <0.71 ...                            | <0.14 ...                            | 0.68 <sup>0.12</sup> <sub>0.01</sub>  | 1.22 <sup>0.06</sup> <sub>0.1</sub>   | 0.73 <sup>0.14</sup> <sub>0.02</sub> | 1.8 <sup>0.31</sup> <sub>0.09</sub>   | 0.03 <sup>0.2</sup> <sub>0.1</sub>   |
| 2M17183459 | 0.07 <sup>0.02</sup> <sub>0.14</sub>  | <1.17 ...                            | <1.21 ...                            | <0.37 ...                            | 0.67 <sup>0.08</sup> <sub>0.04</sub>  | 1.48 <sup>0.01</sup> <sub>0.1</sub>   | 1 <sup>0.14</sup> <sub>0.01</sub>    | 1.37 <sup>0.03</sup> <sub>0.09</sub>  | 0.34 <sup>0.01</sup> <sub>0.03</sub> |
| 2M17214096 | -0.11 <sup>0.1</sup> <sub>0.04</sub>  | <0.72 ...                            | 1 <sup>0.06</sup> <sub>0.04</sub>    | <0.48 ...                            | 0.64 <sup>0.14</sup> <sub>0.01</sub>  | 1.32 <sup>0.04</sup> <sub>0.09</sub>  | 1.02 <sup>0.12</sup> <sub>0.04</sub> | 2.04 <sup>0.02</sup> <sub>0.1</sub>   | 0.44 <sup>0.09</sup> <sub>0.11</sub> |
| 2M17502038 | -0.12 <sup>0.09</sup> <sub>0.09</sub> | <0.61 ...                            | 1.16 <sup>0.07</sup> <sub>0.1</sub>  | <0.16 ...                            | 0.7 <sup>0.15</sup> <sub>0.1</sub>    | 1.42 <sup>0.17</sup> <sub>0.1</sub>   | 0.75 <sup>0.11</sup> <sub>0</sub>    | 1.69 <sup>0.1</sup> <sub>0.1</sub>    | 0.27 <sup>0.2</sup> <sub>0.1</sub>   |
| 2M18120031 | 0.01 <sup>0.12</sup> <sub>0.1</sub>   | 0.97 <sup>0.07</sup> <sub>0.47</sub> | 0.96 <sup>0.04</sup> <sub>0.1</sub>  | <0.12 ...                            | 0.57 <sup>0.12</sup> <sub>0.05</sub>  | 1.22 <sup>0.03</sup> <sub>0.1</sub>   | 0.76 <sup>0.12</sup> <sub>0.03</sub> | 1.65 <sup>0.08</sup> <sub>0.1</sub>   | 0.35 <sup>0.16</sup> <sub>0.17</sub> |
| 2M19105369 | 0.04 <sup>0.2</sup> <sub>0.84</sub>   | 1.42 <sup>0.19</sup> <sub>0.64</sub> | <0.97 ...                            | <0.27 ...                            | 0.61 <sup>0.11</sup> <sub>0.05</sub>  | 1.1 <sup>0.01</sup> <sub>0.09</sub>   | 0.87 <sup>0.11</sup> <sub>0.03</sub> | 1.69 <sup>0.23</sup> <sub>0.1</sub>   | 0.49 <sup>0.2</sup> <sub>0.05</sub>  |
| 2M19214936 | 0.05 <sup>0.05</sup> <sub>0.07</sub>  | 0.6 <sup>0.12</sup> <sub>0.05</sub>  | 0.91 <sup>0.05</sup> <sub>0.12</sub> | 0.12 <sup>0.13</sup> <sub>0.1</sub>  | 0.53 <sup>0.08</sup> <sub>0.05</sub>  | 0.93 <sup>0.01</sup> <sub>0.09</sub>  | 0.71 <sup>0.12</sup> <sub>0.09</sub> | 1.44 <sup>0.24</sup> <sub>0.1</sub>   | 0.21 <sup>0.07</sup> <sub>0.19</sub> |
| 2M19281906 | -0.11 <sup>0.11</sup> <sub>0.08</sub> | <0.7 ...                             | 0.73 <sup>0.05</sup> <sub>0.13</sub> | <0.56 ...                            | 0.47 <sup>0.13</sup> <sub>0.02</sub>  | 0.89 <sup>0.05</sup> <sub>0.09</sub>  | 0.72 <sup>0.11</sup> <sub>0.03</sub> | 1.28 <sup>0.07</sup> <sub>0.1</sub>   | 0.24 <sup>0.07</sup> <sub>0</sub>    |
| star       | [K/Fe]                                | [Ca/Fe]                              | [Ti/Fe]                              | [V/Fe]                               | [Cr/Fe]                               | [Mn/Fe]                               | [Co/Fe]                              | [Ni/Fe]                               | [Ce/Fe]                              |
| 2M00044180 | 0.08 <sup>0.03</sup> <sub>0.01</sub>  | 0.27 <sup>0.02</sup> <sub>0.03</sub> | 0.24 <sup>0.03</sup> <sub>0.01</sub> | <0.72 ...                            | <0.22 ...                             | -0.42 <sup>0.05</sup> <sub>0.01</sub> | <0.15 ...                            | 0.11 <sup>0.07</sup> <sub>0.06</sub>  | <0.02 ...                            |
| 2M12071315 | 0.35 <sup>0.02</sup> <sub>0.27</sub>  | 0.19 <sup>0.08</sup> <sub>0.01</sub> | 0.25 <sup>0.01</sup> <sub>0.14</sub> | <1.78 ...                            | <-0.06 ...                            | -0.2 <sup>0.11</sup> <sub>0.1</sub>   | <0.43 ...                            | 0.06 <sup>0.13</sup> <sub>0</sub>     | 0.67 <sup>0.09</sup> <sub>0.33</sub> |
| 2M13314691 | 0.06 <sup>0.06</sup> <sub>0.09</sub>  | 0.31 <sup>0.02</sup> <sub>0.09</sub> | 0.4 <sup>0.1</sup> <sub>0.26</sub>   | 0.23 <sup>0.04</sup> <sub>0.1</sub>  | 0.04 <sup>0.05</sup> <sub>0.01</sub>  | -0.33 <sup>0.04</sup> <sub>0</sub>    | 0.09 <sup>0.11</sup> <sub>0.02</sub> | 0.09 <sup>0.05</sup> <sub>0.03</sub>  | 0.79 <sup>0.08</sup> <sub>0.17</sub> |
| 2M13472354 | <0.36 ...                             | 0.12 <sup>0.05</sup> <sub>0.08</sub> | <0.58 ...                            | ... ...                              | <0.56 ...                             | <0.19 ...                             | <1.47 ...                            | 0.18 <sup>0.1</sup> <sub>0.1</sub>    | <0.77 ...                            |
| 2M13535604 | 0.16 <sup>0.03</sup> <sub>0.19</sub>  | 0.28 <sup>0.1</sup> <sub>0.06</sub>  | 0.16 <sup>0.07</sup> <sub>0.1</sub>  | <0.89 ...                            | <0.25 ...                             | -0.06 <sup>0.24</sup> <sub>0.19</sub> | <0.51 ...                            | 0.28 <sup>0.12</sup> <sub>0.01</sub>  | 0.85 <sup>0.1</sup> <sub>0.09</sub>  |
| 2M16092248 | 0.09 <sup>0.04</sup> <sub>0.1</sub>   | 0.15 <sup>0.07</sup> <sub>0.01</sub> | 0.32 <sup>0.2</sup> <sub>0.05</sub>  | <0.17 ...                            | <-0.07 ...                            | <-0.45 ...                            | 0.21 <sup>0.08</sup> <sub>0.04</sub> | 0.2 <sup>0.05</sup> <sub>0</sub>      | 0.78 <sup>0.11</sup> <sub>0.09</sub> |
| 2M16482145 | 0.12 <sup>0.11</sup> <sub>0.01</sub>  | 0.25 <sup>0.05</sup> <sub>0.07</sub> | 0.43 <sup>0.16</sup> <sub>0.09</sub> | <0.45 ...                            | <0.03 ...                             | -0.11 <sup>0.27</sup> <sub>0.01</sub> | 0.04 <sup>0.12</sup> <sub>0</sub>    | 0.02 <sup>0.05</sup> <sub>0.1</sub>   | 0.68 <sup>0.09</sup> <sub>0.58</sub> |
| 2M17033361 | 0.17 <sup>0.01</sup> <sub>0.11</sub>  | 0.38 <sup>0.13</sup> <sub>0.01</sub> | 0.7 <sup>0.21</sup> <sub>0.08</sub>  | <0.71 ...                            | <-0.16 ...                            | 0.00 <sup>0.25</sup> <sub>0.19</sub>  | 0.28 <sup>0.15</sup> <sub>0.04</sub> | 0.02 <sup>0.24</sup> <sub>0</sub>     | 1.04 <sup>0.14</sup> <sub>0.04</sub> |
| 2M17183459 | 0.06 <sup>0.05</sup> <sub>0.06</sub>  | 0.27 <sup>0.1</sup> <sub>0</sub>     | 0.77 <sup>0.15</sup> <sub>0.07</sub> | <1.23 ...                            | <0.27 ...                             | -0.18 <sup>0.13</sup> <sub>0.02</sub> | <0.48 ...                            | 0.07 <sup>0.12</sup> <sub>0</sub>     | 0.68 <sup>0.23</sup> <sub>0.3</sub>  |
| 2M17214096 | 0.16 <sup>0.03</sup> <sub>0.07</sub>  | 0.04 <sup>0.11</sup> <sub>0.08</sub> | 0.32 <sup>0.1</sup> <sub>0.1</sub>   | <0.63 ...                            | <0.14 ...                             | -0.26 <sup>0.05</sup> <sub>0.03</sub> | 0.19 <sup>0.02</sup> <sub>0.01</sub> | 0.1 <sup>0.05</sup> <sub>0.04</sub>   | 0.79 <sup>0.1</sup> <sub>0.09</sub>  |
| 2M17502038 | 0.38 <sup>0.06</sup> <sub>0.08</sub>  | 0.48 <sup>0.03</sup> <sub>0.08</sub> | 0.49 <sup>0.15</sup> <sub>0.06</sub> | 0.43 <sup>0.06</sup> <sub>0.03</sub> | 0.12 <sup>0.05</sup> <sub>0.24</sub>  | -0.28 <sup>0.07</sup> <sub>0.06</sub> | 0.06 <sup>0.04</sup> <sub>0.02</sub> | -0.19 <sup>0.19</sup> <sub>0.27</sub> | 0.57 <sup>0.15</sup> <sub>0.1</sub>  |
| 2M18120031 | 0.21 <sup>0.02</sup> <sub>0.02</sub>  | 0.34 <sup>0.02</sup> <sub>0.06</sub> | 0.45 <sup>0.14</sup> <sub>0.25</sub> | 0.28 <sup>0.07</sup> <sub>0.1</sub>  | <0.14 ...                             | -0.21 <sup>0.3</sup> <sub>0.1</sub>   | 0.07 <sup>0.06</sup> <sub>0.1</sub>  | -0.03 <sup>0.11</sup> <sub>0.12</sub> | 0.74 <sup>0.17</sup> <sub>0.11</sub> |
| 2M19105369 | 0.26 <sup>0.05</sup> <sub>0.04</sub>  | 0.23 <sup>0.15</sup> <sub>0.07</sub> | 0.55 <sup>0.2</sup> <sub>0.02</sub>  | <2.06 ...                            | <0.19 ...                             | -0.1 <sup>0.12</sup> <sub>0.01</sub>  | <0.5 ...                             | 0.1 <sup>0.13</sup> <sub>0</sub>      | 1.11 <sup>0.05</sup> <sub>0.09</sub> |
| 2M19214936 | 0.11 <sup>0.01</sup> <sub>0.12</sub>  | 0.31 <sup>0.01</sup> <sub>0.13</sub> | 0.36 <sup>0.19</sup> <sub>0.14</sub> | 0.17 <sup>0.07</sup> <sub>0.12</sub> | -0.09 <sup>0.08</sup> <sub>0.27</sub> | -0.23 <sup>0.2</sup> <sub>0.05</sub>  | 0.16 <sup>0.02</sup> <sub>0.03</sub> | -0.01 <sup>0.06</sup> <sub>0.04</sub> | 0.7 <sup>0.13</sup> <sub>0.15</sub>  |
| 2M19281906 | 0.13 <sup>0.04</sup> <sub>0.07</sub>  | 0.19 <sup>0.02</sup> <sub>0.01</sub> | 0.38 <sup>0.2</sup> <sub>0.1</sub>   | <0.63 ...                            | -0.03 <sup>0.27</sup> <sub>0.08</sub> | -0.05 <sup>0.29</sup> <sub>0.1</sub>  | 0.13 <sup>0.06</sup> <sub>0.03</sub> | 0.15 <sup>0.04</sup> <sub>0.02</sub>  | 0.75 <sup>0.13</sup> <sub>0.22</sub> |

All abundances are in logarithmic scale, relative to their metallicity and to the Solar values[1] such as displayed in Fig.1, 4 and 6 . The upper indices show the random errors while the bottom indices show the systematic errors.

Supplementary Table 4: Abundances of the P-normal stars

| star       | [C/Fe]                                | [N/Fe]                               | [O/Fe]                               | [Na/Fe]                              | [Mg/Fe]                               | [Al/Fe]                               | [Si/Fe]                               | [P/Fe]                                | [S/Fe]                               |
|------------|---------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|--------------------------------------|
| 2M00022364 | 0.24 <sup>0.19</sup> <sub>0.13</sub>  | 0.38 <sup>0.07</sup> <sub>0.1</sub>  | <0.56 ...                            | <0.29 ...                            | 0.43 <sup>0.08</sup> <sub>0.11</sub>  | 0.45 <sup>0.12</sup> <sub>0.17</sub>  | 0.37 <sup>0.09</sup> <sub>0.05</sub>  | <0.51 ...                             | 0.26 <sup>0.17</sup> <sub>0.14</sub> |
| 2M01262518 | 0.29 <sup>0.18</sup> <sub>0.02</sub>  | 0.2 <sup>0.03</sup> <sub>0.1</sub>   | 0.52 <sup>0.17</sup> <sub>0.1</sub>  | <0.47 ...                            | 0.4 <sup>0.07</sup> <sub>0.08</sub>   | 0.45 <sup>0.09</sup> <sub>0.14</sub>  | 0.34 <sup>0.09</sup> <sub>0.02</sub>  | <0.32 ...                             | 0.27 <sup>0.17</sup> <sub>0.05</sub> |
| 2M01271266 | 0.09 <sup>0.06</sup> <sub>0.15</sub>  | 0.17 <sup>0.03</sup> <sub>0.06</sub> | 0.61 <sup>0.11</sup> <sub>0.09</sub> | 0.02 <sup>0.18</sup> <sub>0.1</sub>  | 0.4 <sup>0.11</sup> <sub>0.03</sub>   | 0.36 <sup>0.02</sup> <sub>0.02</sub>  | 0.3 <sup>0.07</sup> <sub>0.03</sub>   | 0.41 <sup>0.28</sup> <sub>0.09</sub>  | 0.34 <sup>0.17</sup> <sub>0.1</sub>  |
| 2M02150319 | 0.32 <sup>0.03</sup> <sub>0.23</sub>  | 0.23 <sup>0.08</sup> <sub>0.48</sub> | 0.61 <sup>0.05</sup> <sub>0.09</sub> | 0.46 <sup>0.19</sup> <sub>0.1</sub>  | 0.41 <sup>0.09</sup> <sub>0.04</sub>  | 0.37 <sup>0.00</sup> <sub>0.00</sub>  | 0.25 <sup>0.07</sup> <sub>0.04</sub>  | <-0.25 ...                            | 0.18 <sup>0.11</sup> <sub>0.1</sub>  |
| 2M07404920 | 0.13 <sup>0.09</sup> <sub>0.12</sub>  | 0.19 <sup>0.08</sup> <sub>0.15</sub> | 0.54 <sup>0.04</sup> <sub>0.11</sub> | 0.09 <sup>0.14</sup> <sub>0.04</sub> | 0.34 <sup>0.13</sup> <sub>0.1</sub>   | 0.44 <sup>0.09</sup> <sub>0.03</sub>  | 0.3 <sup>0.07</sup> <sub>0.03</sub>   | <0.67 ...                             | 0.27 <sup>0.08</sup> <sub>0.16</sub> |
| 2M07461742 | 0.22 <sup>0.13</sup> <sub>0.06</sub>  | 0.24 <sup>0.05</sup> <sub>0.06</sub> | 0.6 <sup>0.03</sup> <sub>0.04</sub>  | <0.38 ...                            | 0.33 <sup>0.05</sup> <sub>0.06</sub>  | 0.36 <sup>0.00</sup> <sub>0.00</sub>  | 0.24 <sup>0.06</sup> <sub>0.03</sub>  | <0.66 ...                             | 0.14 <sup>0.1</sup> <sub>0.03</sub>  |
| 2M11202609 | 0.29 <sup>0.03</sup> <sub>0.15</sub>  | 0.46 <sup>0.04</sup> <sub>0.01</sub> | 0.5 <sup>0.05</sup> <sub>0.01</sub>  | 0.53 <sup>0.12</sup> <sub>0.1</sub>  | 0.4 <sup>0.13</sup> <sub>0.04</sub>   | -0.02 <sup>0.03</sup> <sub>0.04</sub> | 0.25 <sup>0.1</sup> <sub>0.08</sub>   | <0.59 ...                             | 0.45 <sup>0.2</sup> <sub>0.06</sub>  |
| 2M13240275 | 0.15 <sup>0.24</sup> <sub>0.21</sub>  | 0.21 <sup>0.15</sup> <sub>0.00</sub> | <0.46 ...                            | <0.39 ...                            | 0.41 <sup>0.1</sup> <sub>0.08</sub>   | 0.38 <sup>0.11</sup> <sub>0.11</sub>  | 0.33 <sup>0.1</sup> <sub>0.06</sub>   | 0.33 <sup>0.33</sup> <sub>0.09</sub>  | 0.32 <sup>0.25</sup> <sub>0.06</sub> |
| 2M15563661 | 0.04 <sup>0.08</sup> <sub>0.00</sub>  | 0.29 <sup>0.03</sup> <sub>0.05</sub> | 0.56 <sup>0.13</sup> <sub>0.03</sub> | 0.28 <sup>0.25</sup> <sub>0.1</sub>  | 0.4 <sup>0.08</sup> <sub>0.09</sub>   | 0.45 <sup>0.05</sup> <sub>0.05</sub>  | 0.29 <sup>0.07</sup> <sub>0.00</sub>  | <0.11 ...                             | 0.18 <sup>0.02</sup> <sub>0.07</sub> |
| 2M16164586 | 0.00 <sup>0.11</sup> <sub>0.09</sub>  | 0.18 <sup>0.04</sup> <sub>0.06</sub> | 0.59 <sup>0.11</sup> <sub>0.04</sub> | <0.29 ...                            | 0.42 <sup>0.08</sup> <sub>0.00</sub>  | 0.38 <sup>0.00</sup> <sub>0.02</sub>  | 0.32 <sup>0.06</sup> <sub>0.01</sub>  | ... ...                               | 0.26 <sup>0.06</sup> <sub>0.04</sub> |
| 2M16471103 | -0.39 <sup>0.12</sup> <sub>0.05</sub> | 1.48 <sup>0.03</sup> <sub>0.1</sub>  | 0.53 <sup>0.1</sup> <sub>0.55</sub>  | 0.39 <sup>0.12</sup> <sub>0.09</sub> | 0.35 <sup>0.08</sup> <sub>0.2</sub>   | 0.44 <sup>0.26</sup> <sub>0.03</sub>  | 0.26 <sup>0.09</sup> <sub>0.06</sub>  | ... ...                               | 0.11 <sup>0.07</sup> <sub>0.08</sub> |
| 2M17142525 | -0.2 <sup>0.14</sup> <sub>0.00</sub>  | 0.2 <sup>0.04</sup> <sub>0.11</sub>  | 0.55 <sup>0.06</sup> <sub>0.1</sub>  | 0.22 <sup>0.17</sup> <sub>0.1</sub>  | 0.31 <sup>0.1</sup> <sub>0.00</sub>   | 0.01 <sup>0.09</sup> <sub>0.02</sub>  | 0.25 <sup>0.07</sup> <sub>0.04</sub>  | <0.58 ...                             | 0.25 <sup>0.15</sup> <sub>0.15</sub> |
| 2M19311218 | 0.15 <sup>0.06</sup> <sub>0.00</sub>  | 0.38 <sup>0.07</sup> <sub>0.02</sub> | 0.6 <sup>0.08</sup> <sub>0.03</sub>  | <-0.02 ...                           | 0.42 <sup>0.1</sup> <sub>0.00</sub>   | 0.55 <sup>0.02</sup> <sub>0.00</sub>  | 0.39 <sup>0.09</sup> <sub>0.00</sub>  | 0.47 <sup>0.2</sup> <sub>0.1</sub>    | 0.33 <sup>0.11</sup> <sub>0.02</sub> |
| 2M19320870 | 0.16 <sup>0.06</sup> <sub>0.06</sub>  | <0.18 ...                            | 0.62 <sup>0.08</sup> <sub>0.14</sub> | <0.1 ...                             | 0.39 <sup>0.11</sup> <sub>0.02</sub>  | 0.5 <sup>0.1</sup> <sub>0.1</sub>     | 0.29 <sup>0.08</sup> <sub>0.04</sub>  | 0.78 <sup>0.2</sup> <sub>0.09</sub>   | 0.33 <sup>0.1</sup> <sub>0.15</sub>  |
| 2M21330531 | 0.09 <sup>0.06</sup> <sub>0.13</sub>  | <0.25 ...                            | 0.65 <sup>0.06</sup> <sub>0.01</sub> | <0.16 ...                            | 0.4 <sup>0.1</sup> <sub>0.08</sub>    | 0.54 <sup>0.03</sup> <sub>0.1</sub>   | 0.44 <sup>0.06</sup> <sub>0.01</sub>  | <0.84 ...                             | 0.27 <sup>0.07</sup> <sub>0.11</sub> |
| star       | [K/Fe]                                | [Ca/Fe]                              | [Ti/Fe]                              | [V/Fe]                               | [Cr/Fe]                               | [Mn/Fe]                               | [Co/Fe]                               | [Ni/Fe]                               | [Ce/Fe]                              |
| 2M00022364 | 0.19 <sup>0.00</sup> <sub>0.04</sub>  | 0.15 <sup>0.04</sup> <sub>0.03</sub> | 0.14 <sup>0.07</sup> <sub>0.74</sub> | ... ...                              | -0.2 <sup>0.1</sup> <sub>0.1</sub>    | -0.41 <sup>0.05</sup> <sub>0.06</sub> | <-0.1 ...                             | 0.03 <sup>0.12</sup> <sub>0.11</sub>  | 0.25 <sup>0.32</sup> <sub>0.1</sub>  |
| 2M01262518 | 0.06 <sup>0.07</sup> <sub>0.16</sub>  | 0.06 <sup>0.01</sup> <sub>0.00</sub> | 0.09 <sup>0.2</sup> <sub>0.86</sub>  | <1.8 ...                             | -0.28 <sup>0.2</sup> <sub>0.1</sub>   | -0.28 <sup>0.25</sup> <sub>0.1</sub>  | <0.12 ...                             | 0.05 <sup>0.04</sup> <sub>0.11</sub>  | <0.11 ...                            |
| 2M01271266 | 0.15 <sup>0.05</sup> <sub>0.28</sub>  | 0.3 <sup>0.04</sup> <sub>0.00</sub>  | 0.38 <sup>0.2</sup> <sub>0.06</sub>  | <-0.88 ...                           | -0.08 <sup>0.00</sup> <sub>0.1</sub>  | -0.37 <sup>0.19</sup> <sub>0.12</sub> | 0.13 <sup>0.18</sup> <sub>0.1</sub>   | 0.05 <sup>0.04</sup> <sub>0.04</sub>  | 0.24 <sup>0.1</sup> <sub>0.11</sub>  |
| 2M02150319 | 0.14 <sup>0.06</sup> <sub>0.03</sub>  | 0.17 <sup>0.01</sup> <sub>0.06</sub> | 0.11 <sup>0.09</sup> <sub>0.05</sub> | <0.34 ...                            | 0.1 <sup>0.00</sup> <sub>0.1</sub>    | -0.32 <sup>0.11</sup> <sub>0.04</sub> | 0.14 <sup>0.18</sup> <sub>0.1</sub>   | 0.18 <sup>0.08</sup> <sub>0.01</sub>  | <-0.2 ...                            |
| 2M07404920 | 0.18 <sup>0.03</sup> <sub>0.07</sub>  | 0.16 <sup>0.02</sup> <sub>0.05</sub> | 0.29 <sup>0.16</sup> <sub>0.13</sub> | <0.36 ...                            | -0.13 <sup>0.06</sup> <sub>0.01</sub> | -0.34 <sup>0.03</sup> <sub>0.14</sub> | 0.07 <sup>0.12</sup> <sub>0.01</sub>  | 0.07 <sup>0.00</sup> <sub>0.06</sub>  | <-0.18 ...                           |
| 2M07461742 | 0.18 <sup>0.03</sup> <sub>0.38</sub>  | 0.22 <sup>0.05</sup> <sub>0.02</sub> | 0.12 <sup>0.14</sup> <sub>0.1</sub>  | <0.55 ...                            | 0.03 <sup>0.06</sup> <sub>0.36</sub>  | -0.18 <sup>0.05</sup> <sub>0.1</sub>  | 0.13 <sup>0.1</sup> <sub>0.1</sub>    | 0.13 <sup>0.05</sup> <sub>0.06</sub>  | 0.1 <sup>0.14</sup> <sub>0.21</sub>  |
| 2M11202609 | 0.27 <sup>0.00</sup> <sub>0.16</sub>  | 0.26 <sup>0.02</sup> <sub>0.05</sub> | 0.63 <sup>0.23</sup> <sub>0.44</sub> | <-0.01 ...                           | 0.00 <sup>0.07</sup> <sub>0.1</sub>   | 0.2 <sup>0.39</sup> <sub>0.46</sub>   | -0.13 <sup>0.08</sup> <sub>0.18</sub> | 0.05 <sup>0.03</sup> <sub>0.02</sub>  | 0.94 <sup>0.15</sup> <sub>0.09</sub> |
| 2M13240275 | 0.11 <sup>0.00</sup> <sub>0.26</sub>  | 0.12 <sup>0.01</sup> <sub>0.05</sub> | 0.2 <sup>0.15</sup> <sub>0.76</sub>  | <0.67 ...                            | -0.07 <sup>0.11</sup> <sub>0.1</sub>  | -0.37 <sup>0.07</sup> <sub>0.07</sub> | <-0.1 ...                             | 0.08 <sup>0.07</sup> <sub>0.1</sub>   | 0.02 <sup>0.13</sup> <sub>0.1</sub>  |
| 2M15563661 | 0.09 <sup>0.04</sup> <sub>0.08</sub>  | 0.22 <sup>0.03</sup> <sub>0.06</sub> | 0.37 <sup>0.28</sup> <sub>0.09</sub> | <-0.08 ...                           | -0.08 <sup>0.24</sup> <sub>0.28</sub> | -0.35 <sup>0.07</sup> <sub>0.08</sub> | 0.11 <sup>0.12</sup> <sub>0.05</sub>  | 0.03 <sup>0.05</sup> <sub>0.04</sub>  | 0.13 <sup>0.06</sup> <sub>0.13</sub> |
| 2M16164586 | 0.14 <sup>0.05</sup> <sub>0.23</sub>  | 0.28 <sup>0.00</sup> <sub>0.00</sub> | 0.15 <sup>0.07</sup> <sub>0.07</sub> | 0.24 <sup>0.11</sup> <sub>0.1</sub>  | 0.14 <sup>0.04</sup> <sub>0.1</sub>   | -0.34 <sup>0.02</sup> <sub>0.01</sub> | -0.28 <sup>0.15</sup> <sub>0.1</sub>  | 0.05 <sup>0.03</sup> <sub>0.04</sub>  | 0.41 <sup>0.03</sup> <sub>0.03</sub> |
| 2M16471103 | 0.16 <sup>0.01</sup> <sub>0.3</sub>   | 0.23 <sup>0.03</sup> <sub>0.12</sub> | 0.56 <sup>0.19</sup> <sub>0.67</sub> | <0.16 ...                            | 0.14 <sup>0.13</sup> <sub>0.1</sub>   | -0.32 <sup>0.01</sup> <sub>0.34</sub> | -0.27 <sup>0.09</sup> <sub>0.1</sub>  | 0.04 <sup>0.04</sup> <sub>0.08</sub>  | 0.37 <sup>0.02</sup> <sub>0.09</sub> |
| 2M17142525 | 0.11 <sup>0.02</sup> <sub>0.05</sub>  | 0.23 <sup>0.01</sup> <sub>0.01</sub> | 0.11 <sup>0.06</sup> <sub>0.42</sub> | <3.11 ...                            | 0.01 <sup>0.08</sup> <sub>0.03</sub>  | -0.2 <sup>0.28</sup> <sub>0.06</sub>  | -0.16 <sup>0.13</sup> <sub>0.1</sub>  | -0.04 <sup>0.07</sup> <sub>0.06</sub> | 0.17 <sup>0.08</sup> <sub>0.07</sub> |
| 2M19311218 | 0.12 <sup>0.03</sup> <sub>0.00</sub>  | 0.14 <sup>0.03</sup> <sub>0.00</sub> | 0.47 <sup>0.26</sup> <sub>0.04</sub> | <0.58 ...                            | 0.00 <sup>0.16</sup> <sub>0.00</sub>  | -0.35 <sup>0.12</sup> <sub>0.00</sub> | <-0.05 ...                            | 0.09 <sup>0.07</sup> <sub>0.00</sub>  | <-0.21 ...                           |
| 2M19320870 | 0.09 <sup>0.02</sup> <sub>0.11</sub>  | 0.26 <sup>0.03</sup> <sub>0.03</sub> | 0.37 <sup>0.31</sup> <sub>0.4</sub>  | <0.62 ...                            | 0.14 <sup>0.09</sup> <sub>0.14</sub>  | -0.44 <sup>0.06</sup> <sub>0.2</sub>  | 0.17 <sup>0.01</sup> <sub>0.01</sub>  | 0.04 <sup>0.09</sup> <sub>0.04</sub>  | <-0.05 ...                           |
| 2M21330531 | 0.05 <sup>0.01</sup> <sub>0.02</sub>  | 0.29 <sup>0.06</sup> <sub>0.04</sub> | 0.18 <sup>0.02</sup> <sub>0.09</sub> | <0.47 ...                            | -0.06 <sup>0.18</sup> <sub>0.1</sub>  | -0.27 <sup>0.26</sup> <sub>0.2</sub>  | 0.11 <sup>0.06</sup> <sub>0.03</sub>  | 0.07 <sup>0.07</sup> <sub>0.01</sub>  | 0.39 <sup>0.07</sup> <sub>0.29</sub> |

All abundances are in logarithmic scale, relative to their metallicity and to the Solar values[1] such as displayed in Fig.1, 4 and 6. The upper indices show the random errors while the bottom indices show the systematic errors.

References

[1] Asplund, M., Grevesse, N., Sauval, A. J., Scott, P. The Chemical Composition of the Sun. Ann. Rev. Astron. Astrophys. **47**, 481-522 (2009)