How PLATO's asteroseismic stellar age constraints could track planetary evolution

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What can asteroseismology do for planets?

— Tides

— Planet destruction

— Formation

— Gravitational scattering
What can PLATO do for asteroseismology?

F5-K7 stars

Core sample of ~15,000 stars

Uses *Gaia* radii measurements

10% main sequence age precision
What can asteroseismology do for planets?

— Gravitational scattering

Prospects for detecting decreasing exoplanet frequency with main-sequence age using PLATO

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2-planet unstable systems

Log_{10}[inner planet orbits]

Semimajor axis ratio

Hill Unstable
Lagrange Unstable
Stable

$e_1 = 0.3$
$e_2 = 0.0$
2-planet unstable systems


Minimum Instability Times

\[
\log_{10} \left[ \text{inner planet orbits} \right] = 5.2 \left( \frac{\mu}{M_J/M_\odot} \right)^{-0.18}
\]

offset

best fit line

\(e_1=0.0, e_2=0.1\)
\(e_1=0.0, e_2=0.2\)
\(e_1=0.0, e_2=0.3\)
\(e_1=0.1, e_2=0.0\)
\(e_1=0.1, e_2=0.1\)
\(e_1=0.1, e_2=0.2\)
\(e_1=0.1, e_2=0.3\)
\(e_1=0.2, e_2=0.0\)
\(e_1=0.2, e_2=0.1\)
\(e_1=0.2, e_2=0.2\)
\(e_1=0.2, e_2=0.3\)
\(e_1=0.3, e_2=0.0\)
\(e_1=0.3, e_2=0.1\)
\(e_1=0.3, e_2=0.2\)
\(e_1=0.3, e_2=0.3\)

\(a_1=10 \text{ au}\)
\(a_1=1.0 \text{ au}\)
\(a_1=0.1 \text{ au}\)
PLATO asteroseismology with 2 planets
Excluding first time bin

$\alpha_1 = 0.1 \text{ au}$

$M_\star = 1.5 M_\odot$
$M_\star = 1.4 M_\odot$
$M_\star = 1.3 M_\odot$
$M_\star = 1.2 M_\odot$
$M_\star = 1.1 M_\odot$
$M_\star = 1.0 M_\odot$
$M_\star = 0.7 M_\odot$

PLATO asteroseismology with 2 planets
More than 2 planets

More than 2 planets


≥3 planets: Necessary empirical relation for detectable trend
More than 2 planets


Excluding first time bin
Conclusions

PLATO stellar age constraints can trace planetary system evolution

Predict decreasing frequency with time

Detectable for ice giants and gas giants
What about after main sequence?

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goo.gl/bVLBc9
Fate of planetary systems: red giant branch

Villaver et al. (2014)
Fate of planetary systems: asymptotic giant branch

Mustill & Villaver (2012)

Time since start of AGB in Myr

Jupiter-mass planets

Earth-mass planets

$R_*$

$2.0M_\odot$