Radial-Velocity Search for Exoplanets around Metal-Rich Stars

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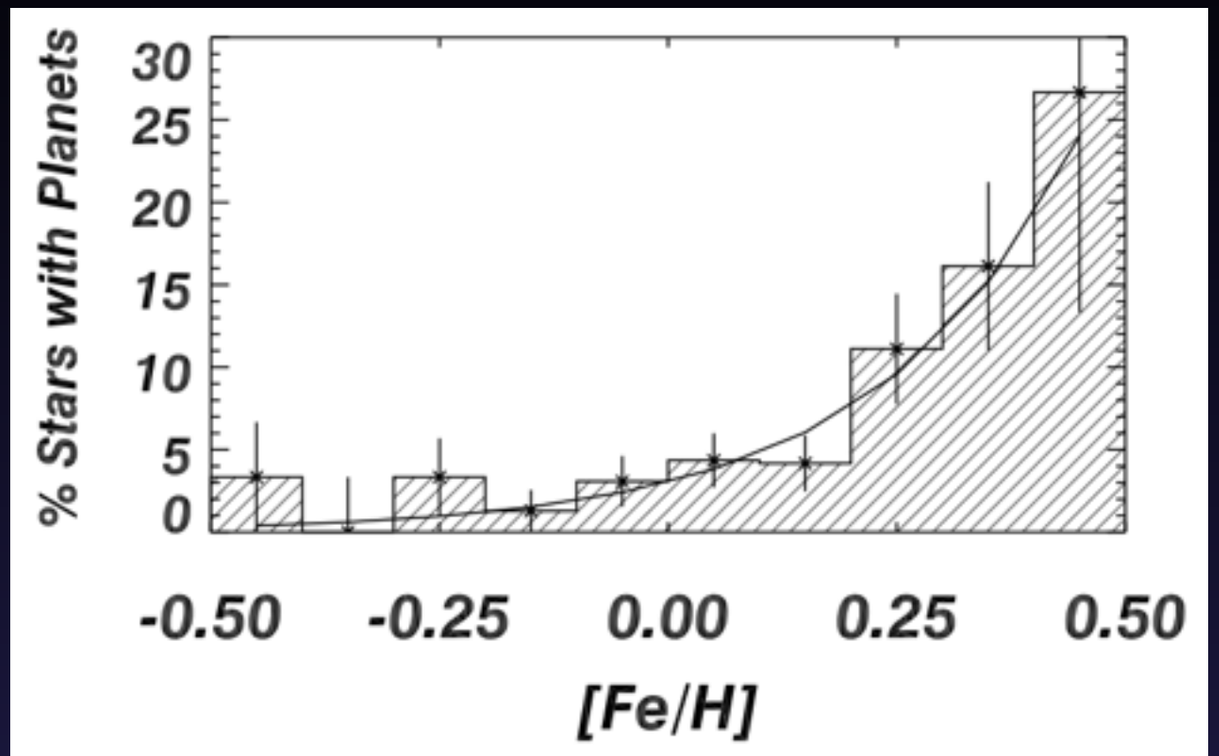
Giant Planet formation: Core-Accretion scenario

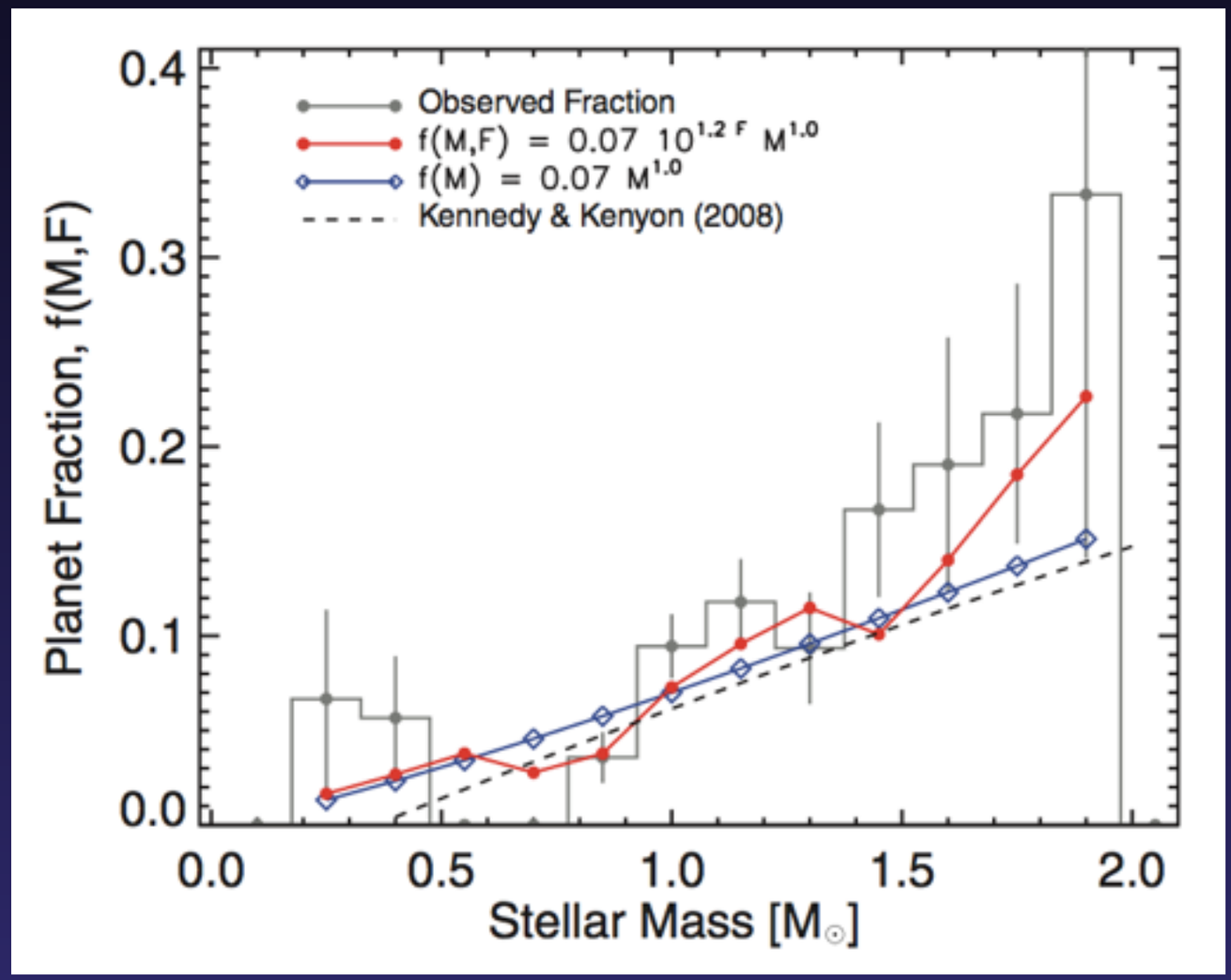
- pass through many physical processes in a protoplanetary disk
  - solid-core grows beyond snow-line (~3AU@Solar system)
    → gas accretion
    inward orbital migration (e.g. Lin & Papaloizou, 85)
    until disk-gas dissipates (~10Myr) (Haisch+01)
    ⇒ disk-lifetime should control the inward migration
  - Orbital evolution
    - Planet-planet scattering (e.g. Nagasawa+ 08)
      - Hot-Jupiter and distant planet (>10AU)

- Planet distribution should have a trend
  with environment of birthplaces (e.g. stellar metallicity, mass)

Planet occurrence vs. [Fe/H] and stellar mass



Fischer and Valenti, 2005

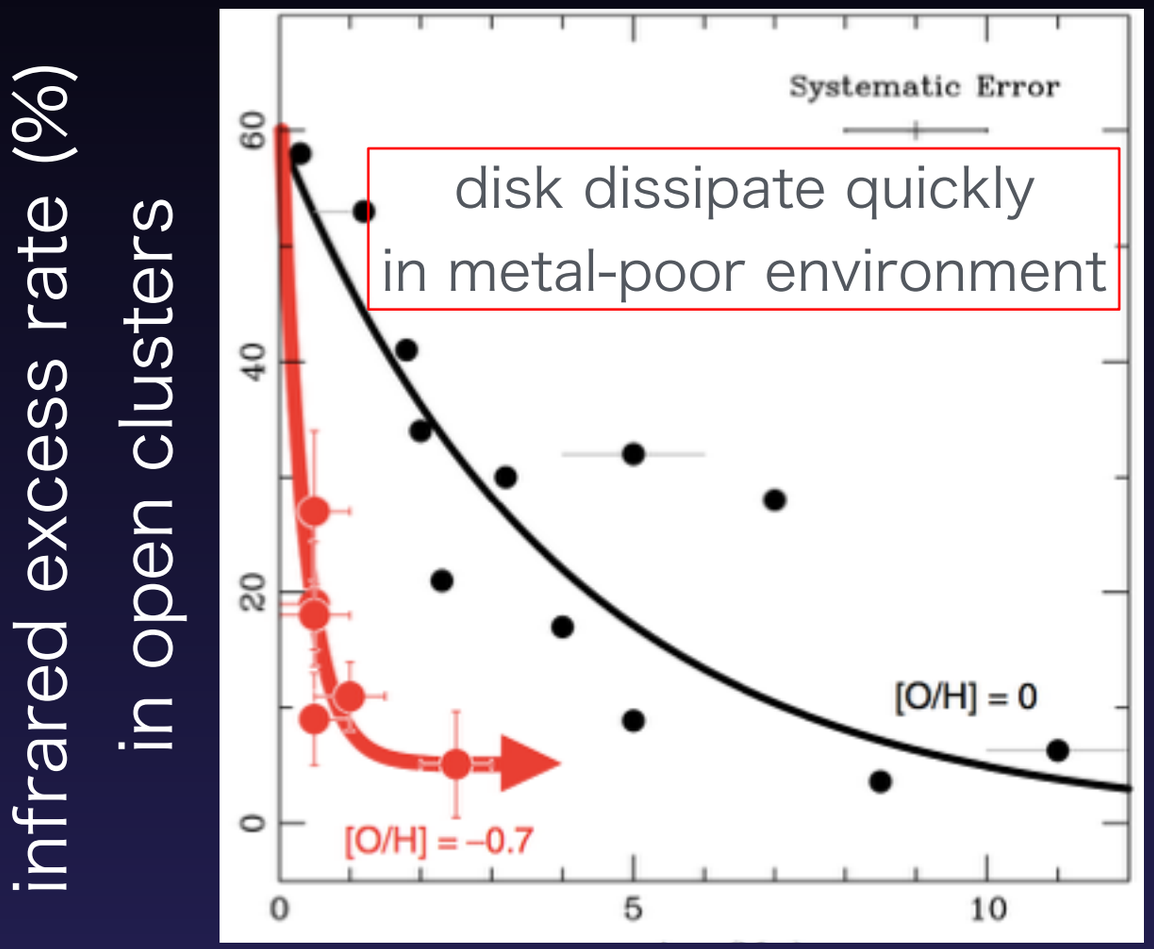


Johnson+, 2010

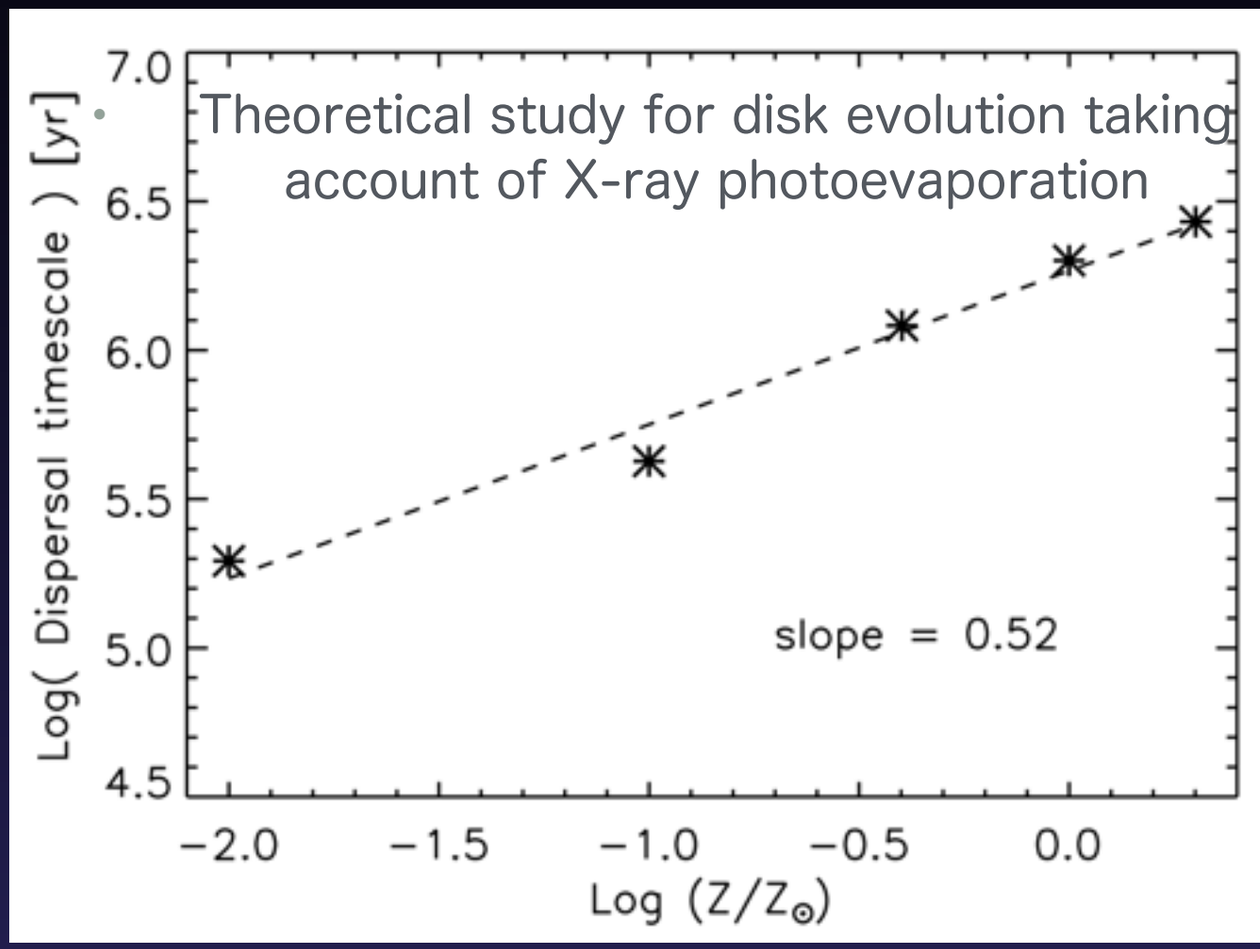
Planet dist. still uncovered…

Why should we consider Metallicity?

Yasui et al. 2010



Elcolano & Clarke 2010



- circumstellar disks in low-metallicity cluster may dissipate in a short time

metallicity should be correlated with
disk-lifetime ⇒ also be with orbital migration?

Radial-Velocity search

2004.07~

Subaru Telescope
National Astronomical Observatory of Japan

2009.08~

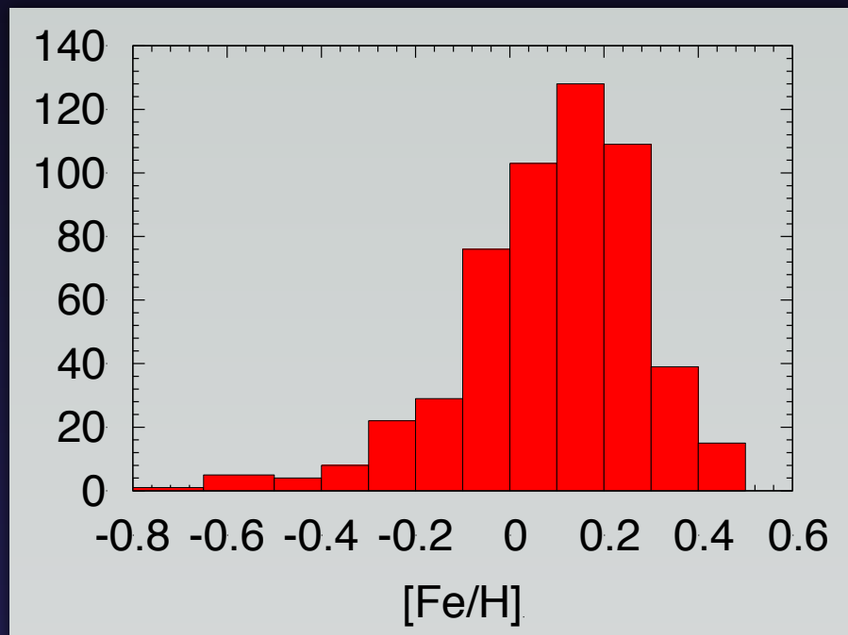
国立天文台
岡山天体物理観測所

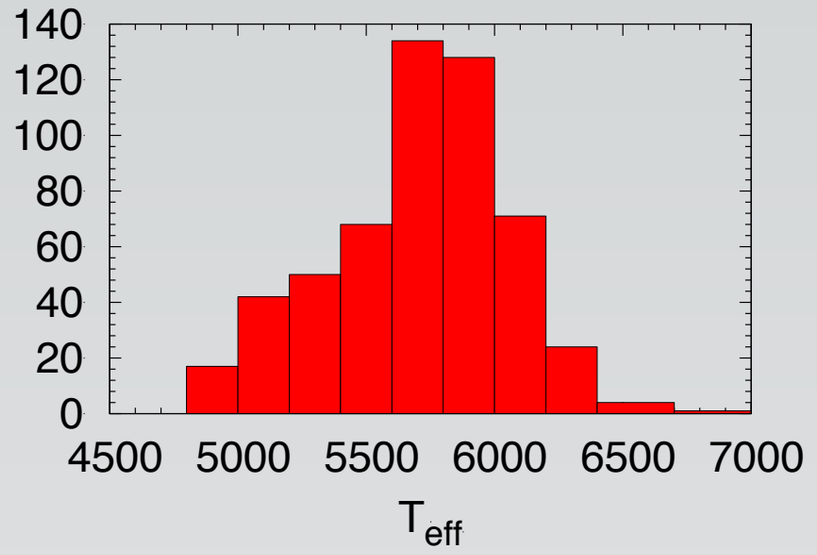
Targets: N2K consortium

- HJ search around 635 metal-rich FGK dwarfs
- ~10 year-long RV observations

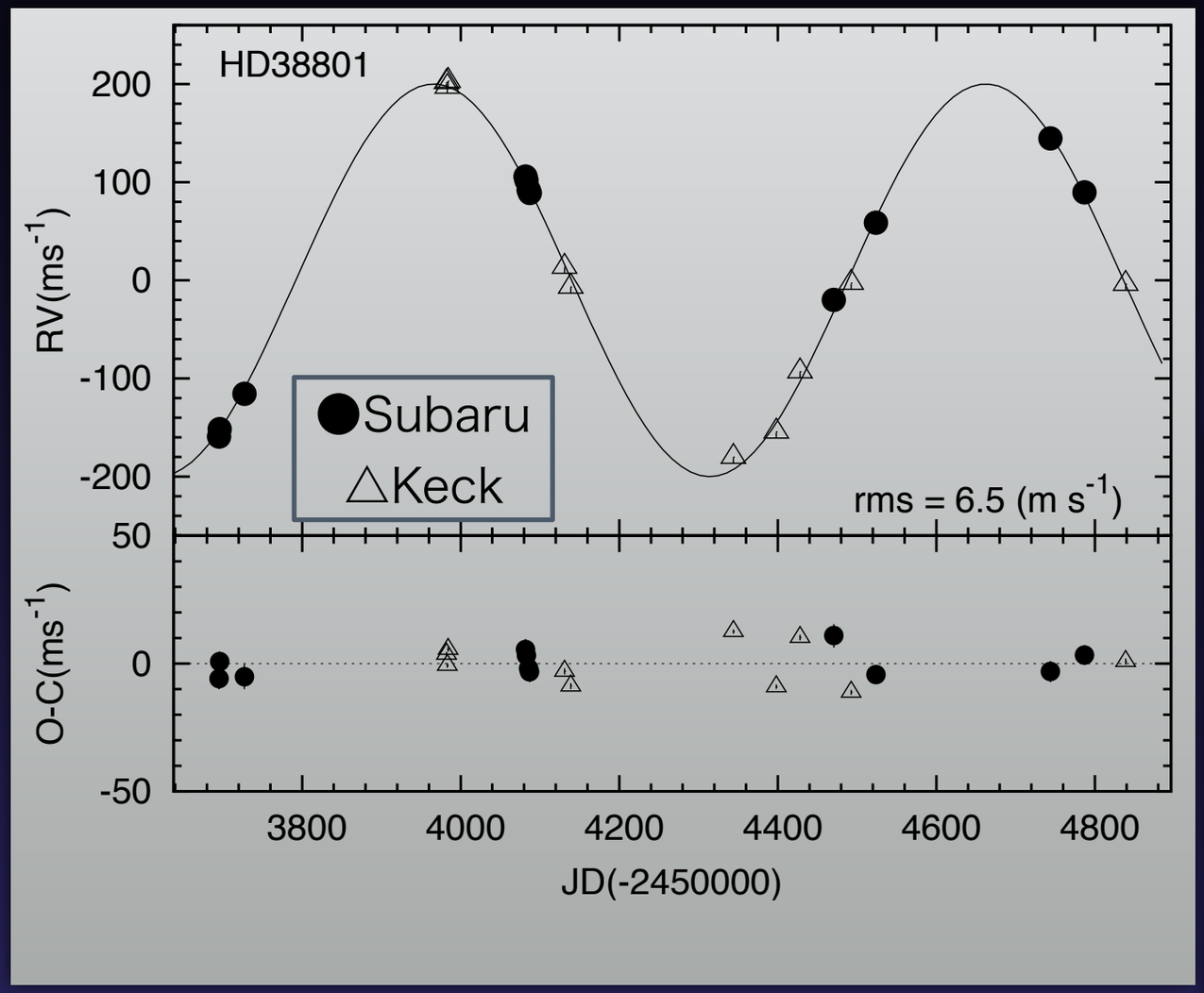
Strategy

- Promising candidates
  ⇒ High cad. obs. @OAO/HIDES
- Uniform sampling
  ⇒ High efficiency obs. @Subaru/HDS



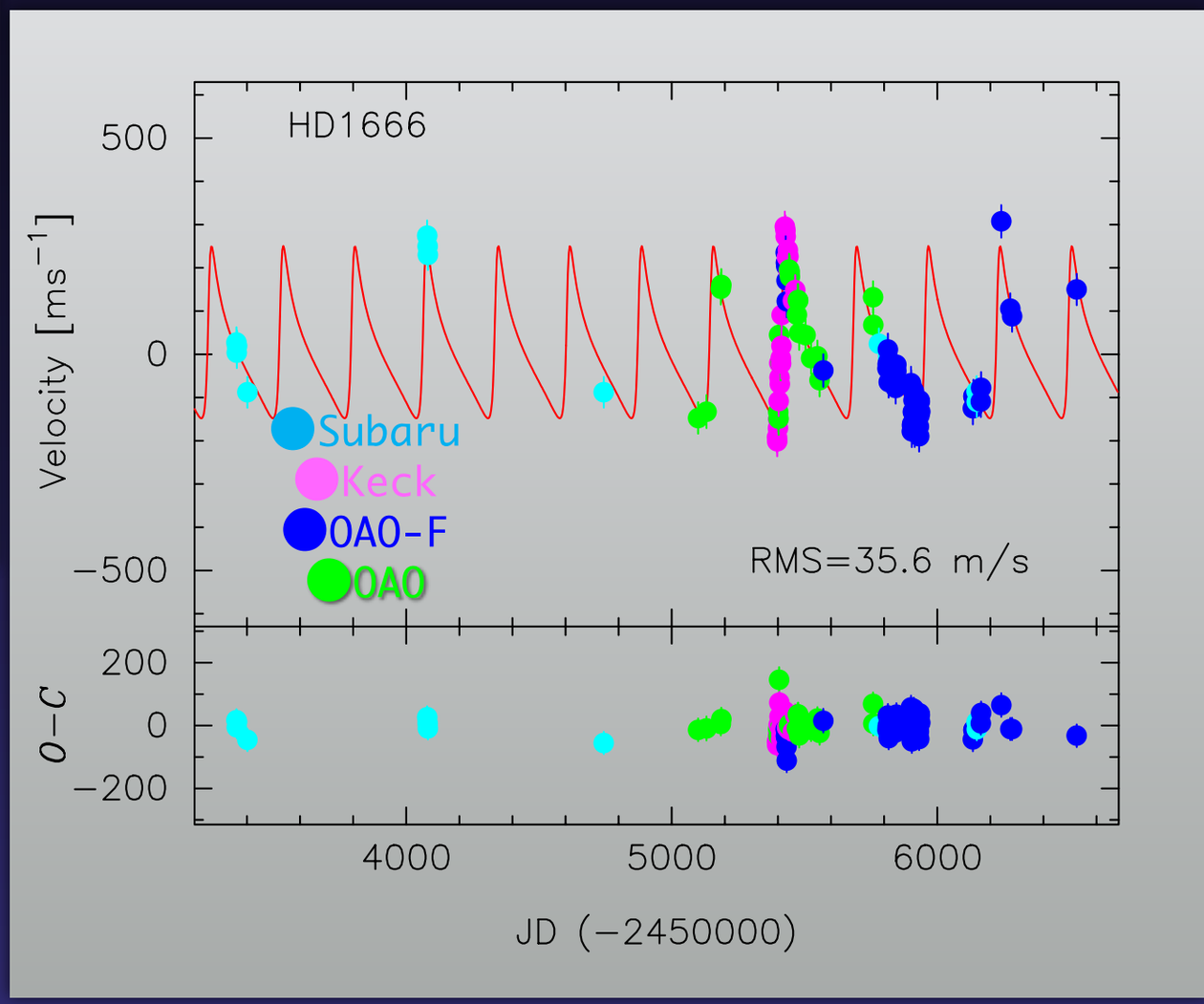


Single and Massive Giant System

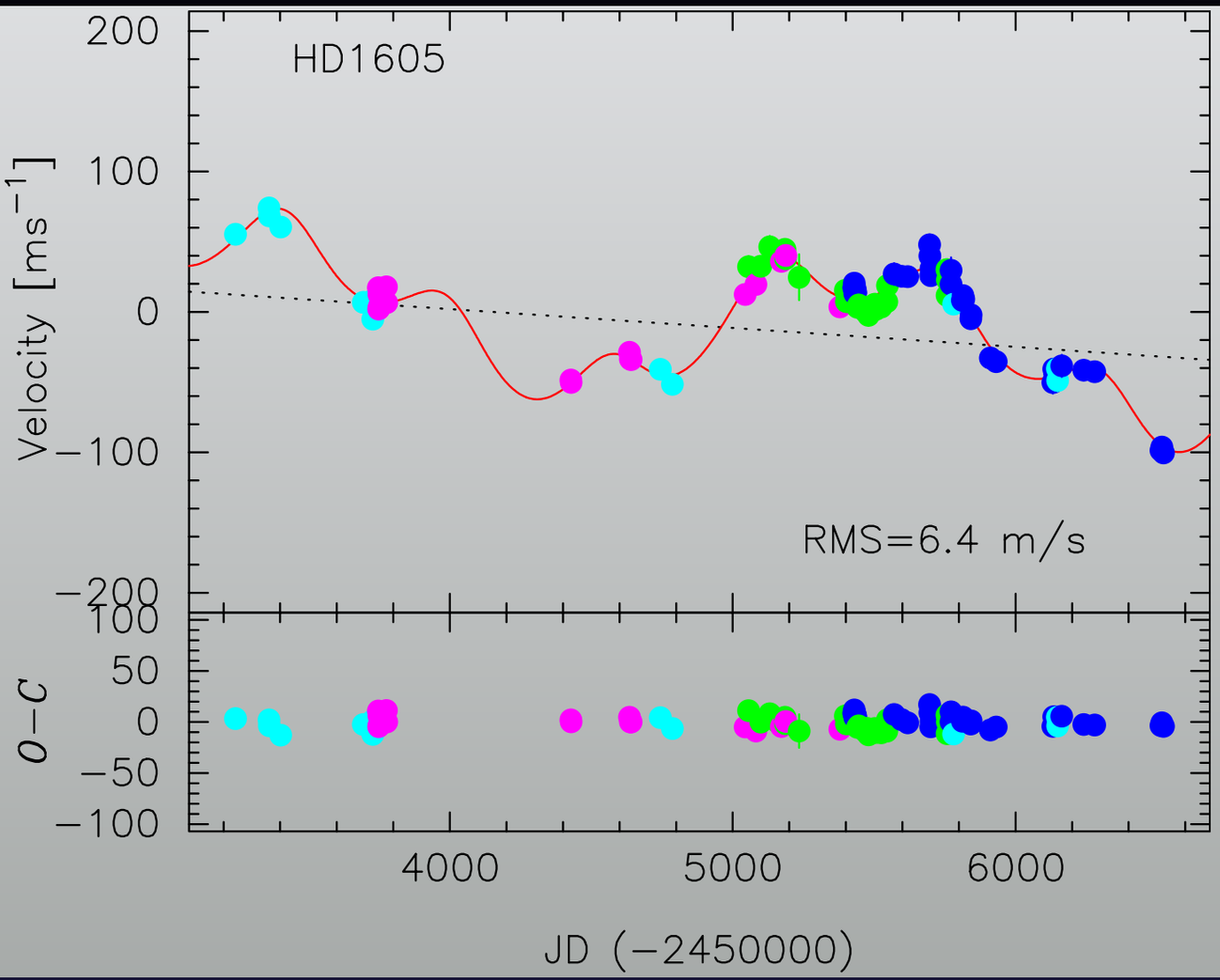


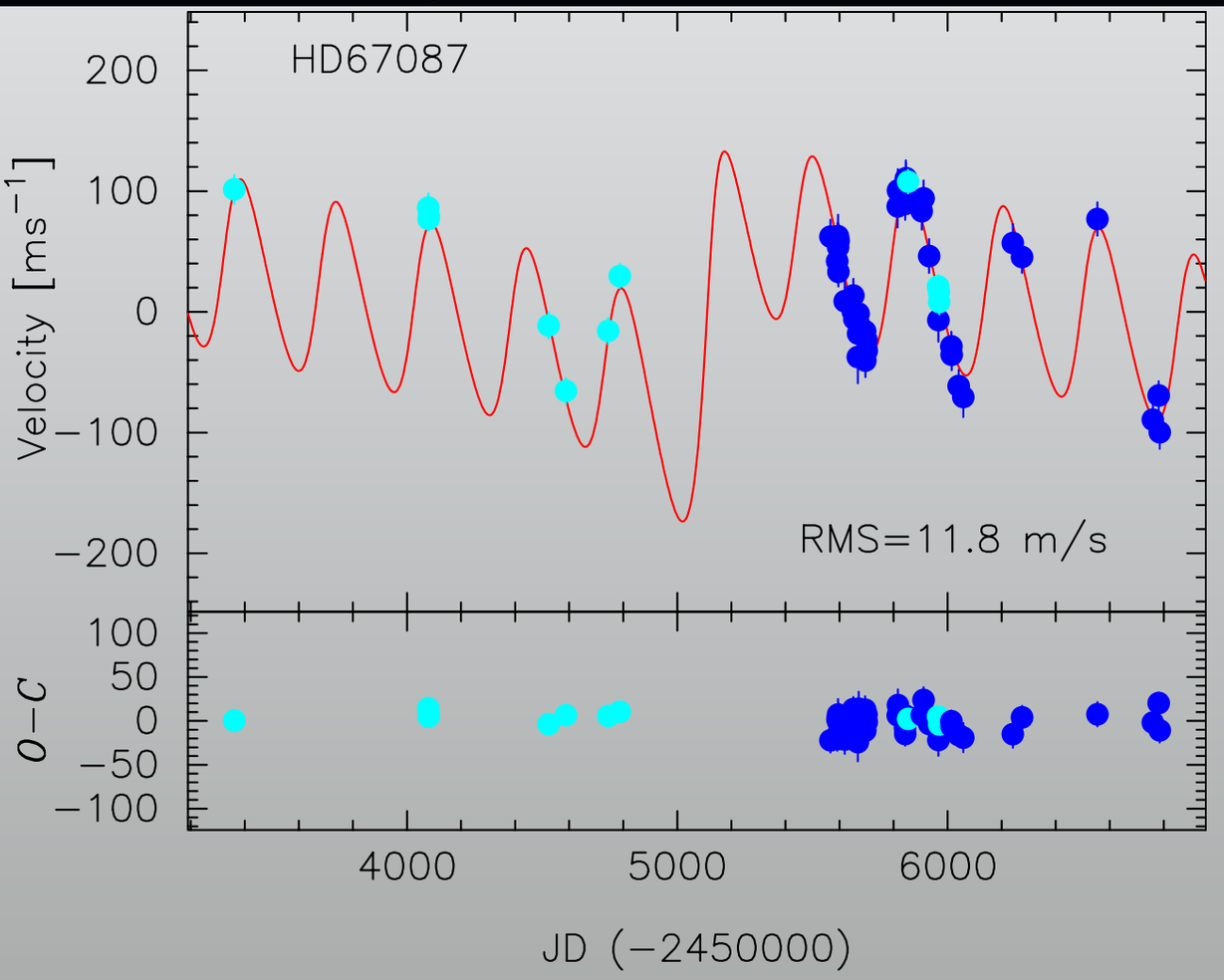
Harakawa+ 2010

Harakawa+ 2015



Multi-Jovian planet system





K1 IV, M_*=1.3$M_\odot$, [Fe/H]=+0.25

b : 550 d, 1M_J

c : 2100 d (3.5 AU), 3M_J

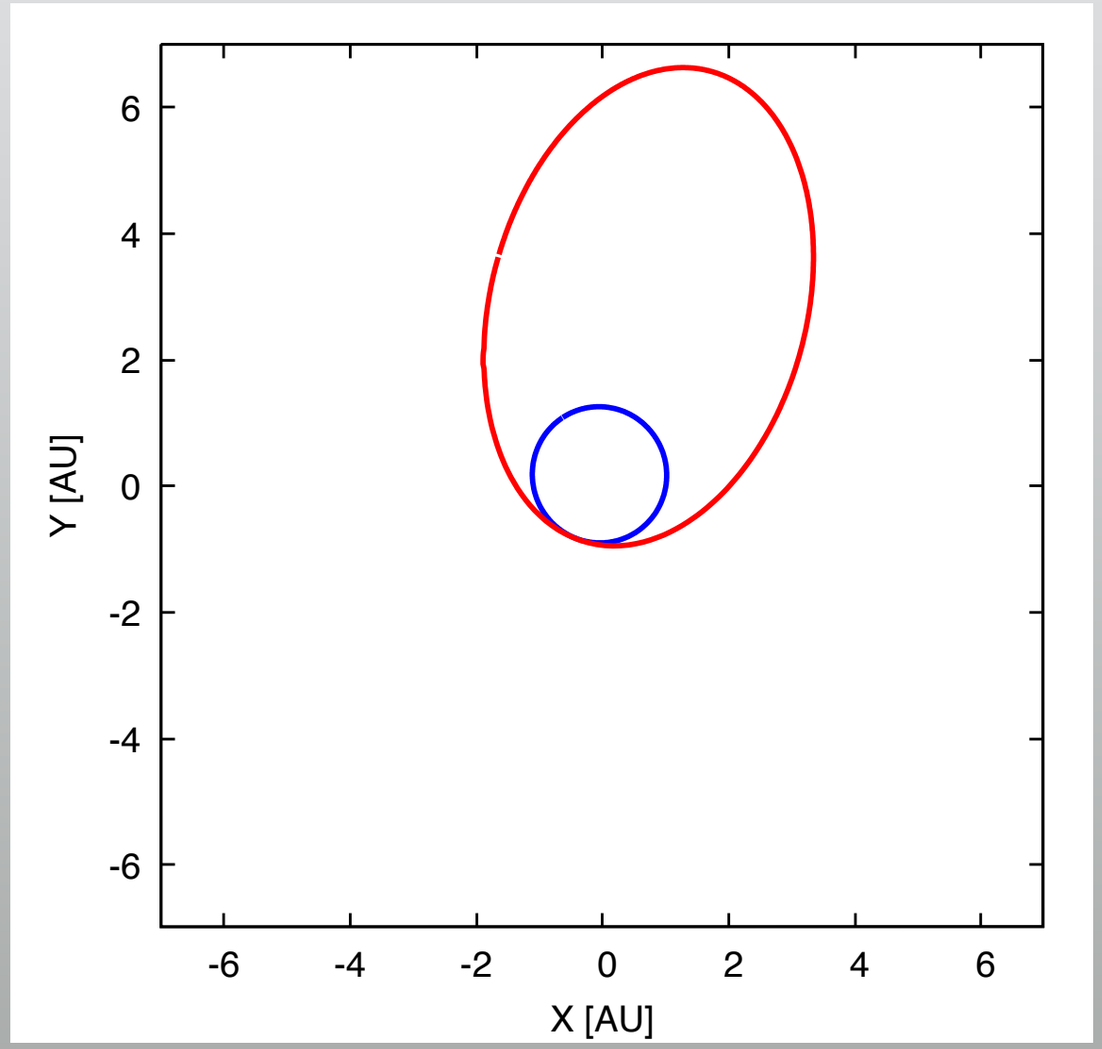
F7V, M_*=1.4$M_\odot$, [Fe/H]=+0.25

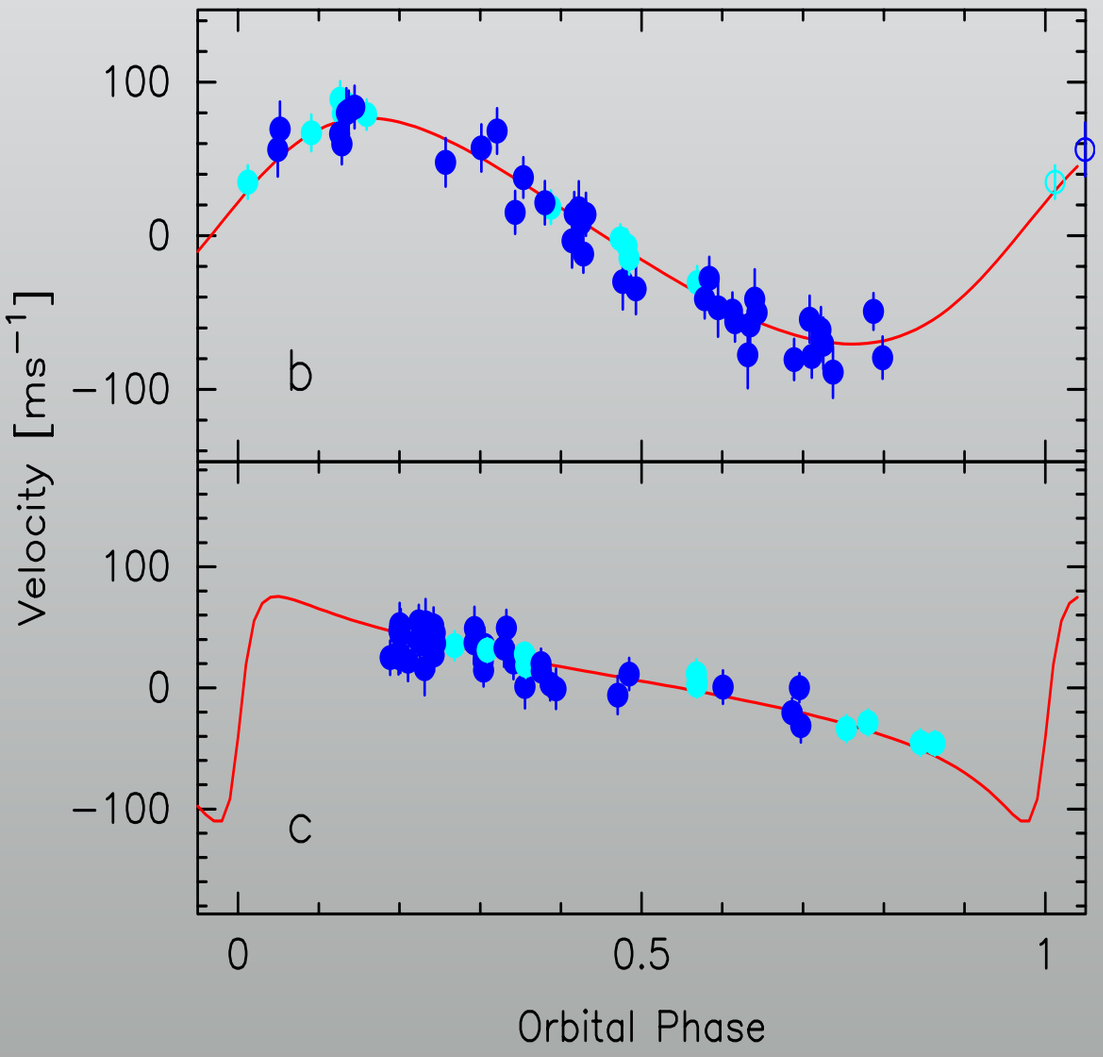
b : 352 d, 3M_J

c : 2374 d (3.9 AU), 3M_J

Harakawa+ 2015

Multi-Jovian planet system



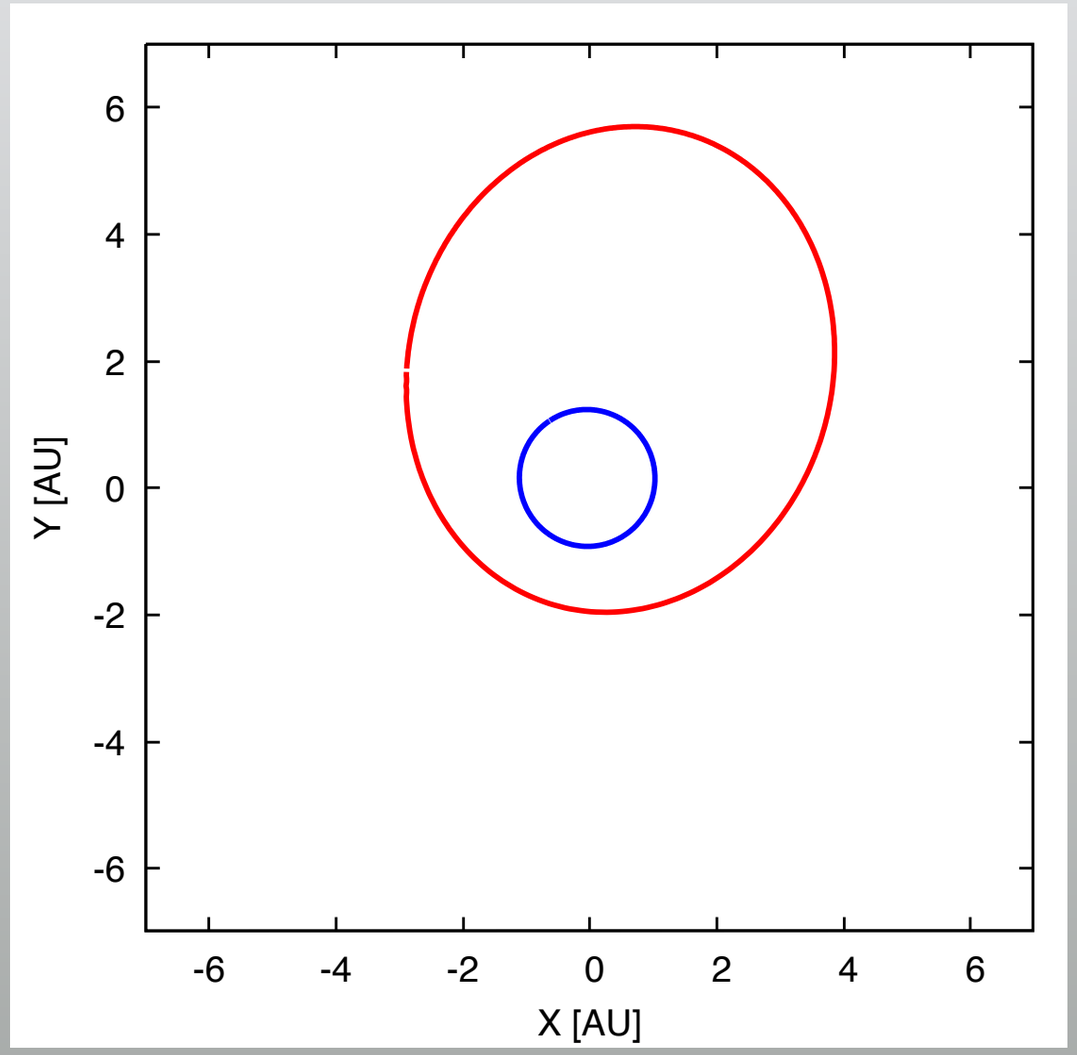


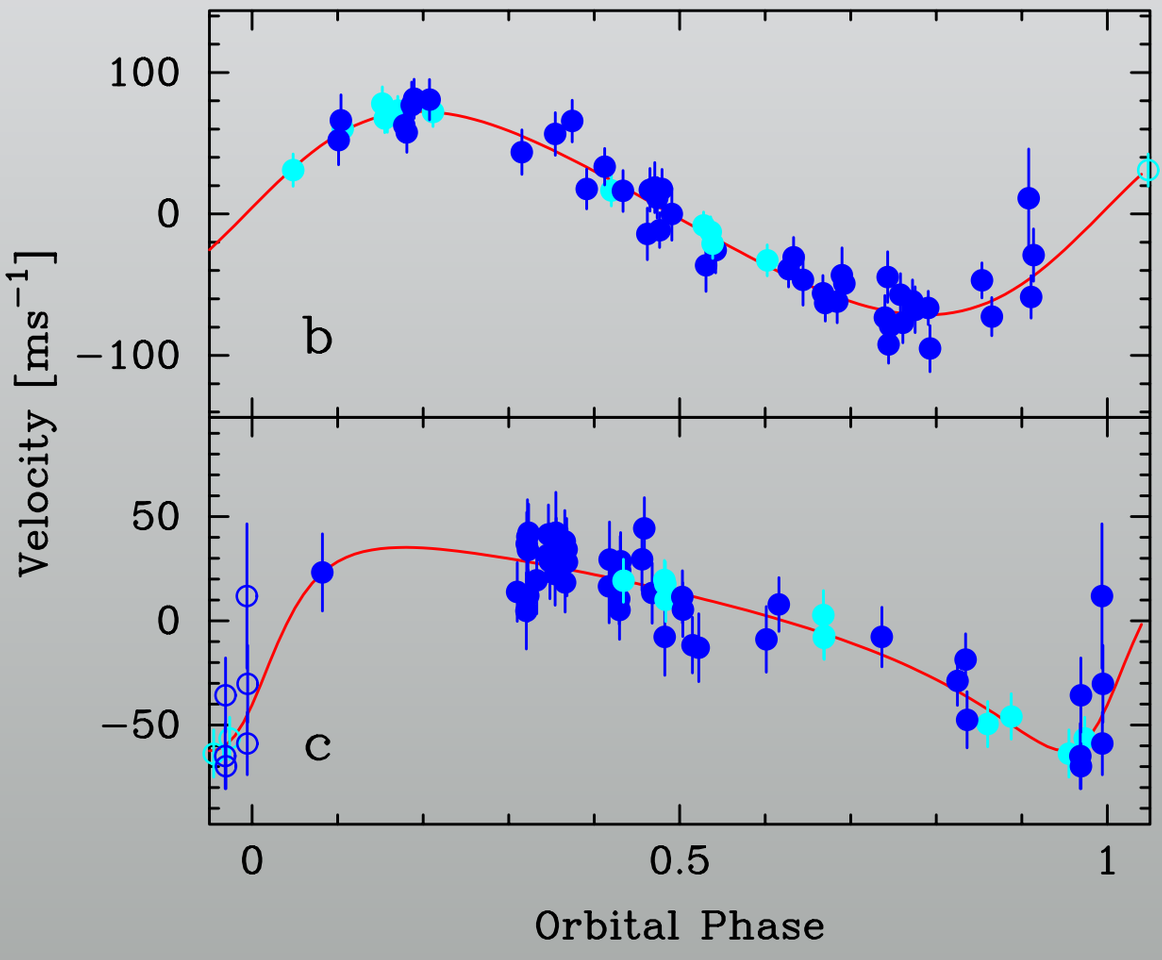
b : e = 0.17

c : e = 0.76($^{+0.17}_{-0.24}$)

※Unstable in almost all geometrics (Petrovich 2015)

Multi-Jovian planet system





Added 7 OAO data

b : e = 0.15±0.02

c : e = 0.50±0.02

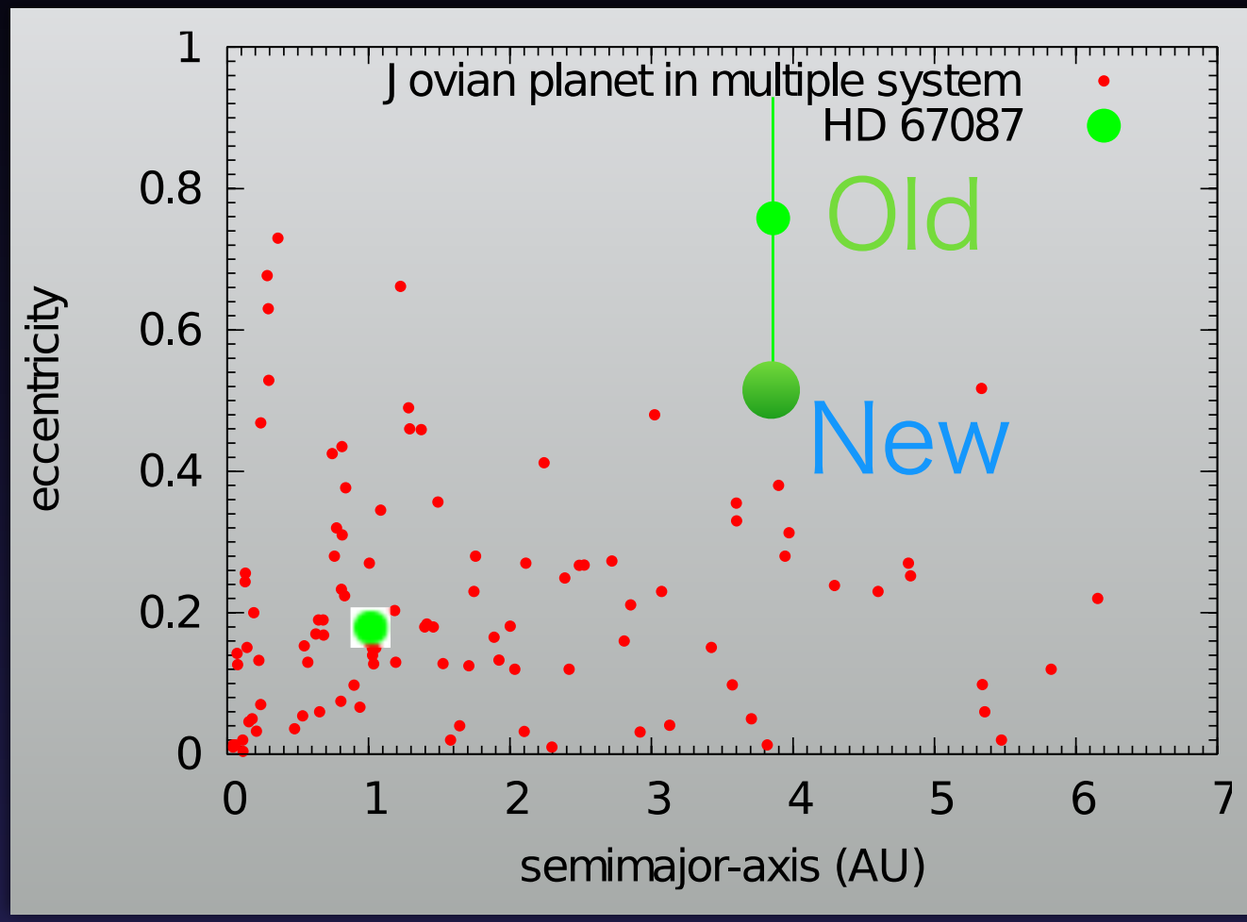
How such strange systems are formed?

HD67087

- ~~The most~~ Still eccentric planet in multiple systems w/o HJs
- No RV trend

HD1605

- Multi-circular orbit system
  - Jup-Sat system analog?
  - only four systems have been reported to date
- Linear RV trend (i.e. additional companion)



Kozai mechanism

· orbital evolution of ecc. and incl. due to perturbation of the outer companion

FIGURE REMOVED

HD67087
(88.8 pc)

Completeness

REMOVED

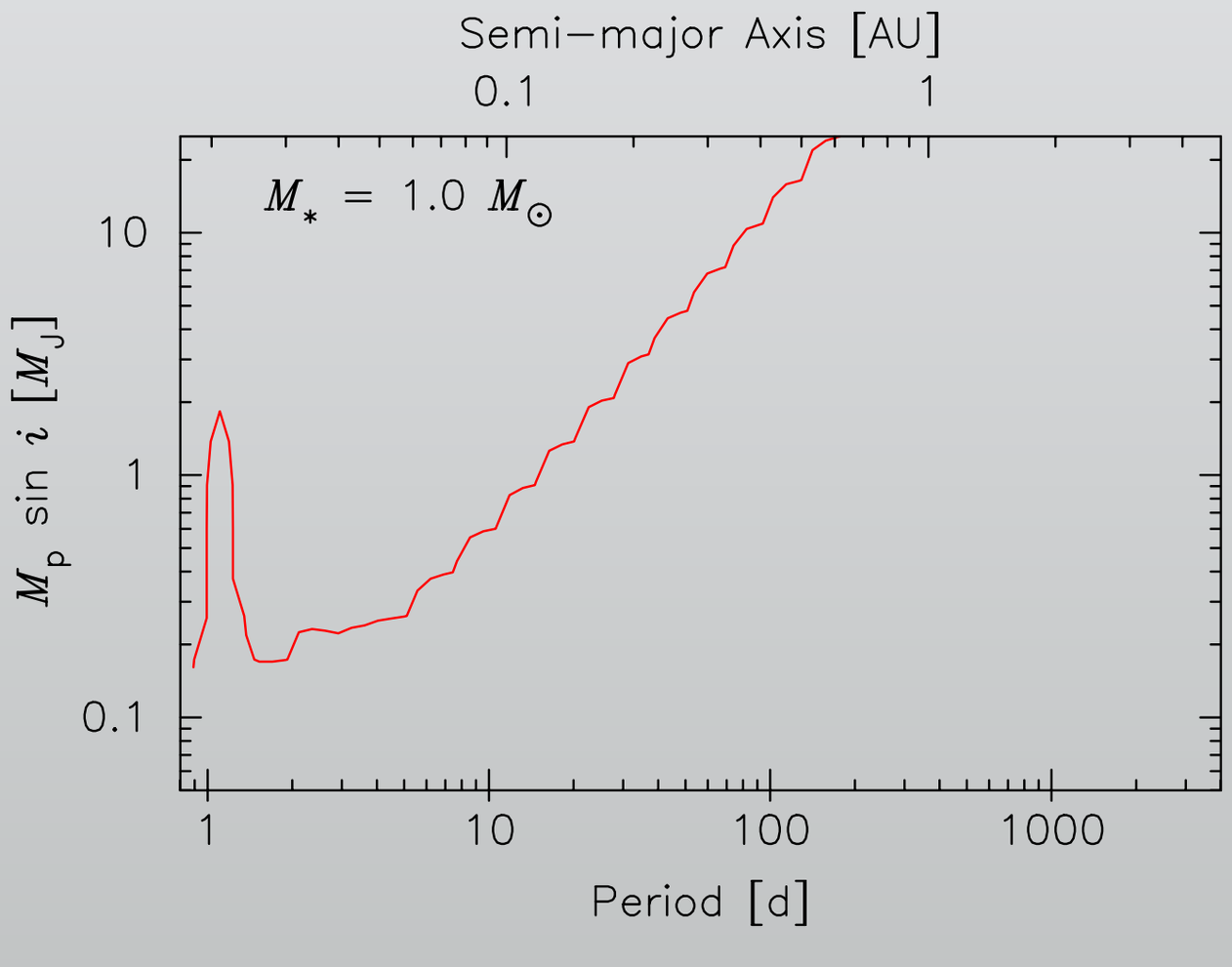
Summary and Future prospects

- Metallicity vs. planet dist. is a key issue
  to unveil planet formation in various environments

- Discovered 5 new planets around 3 stars
  using OAO and Subaru (Harakawa+ 2015)
  - two “strange” multiple systems and the massive host with a massive planet

Next...

- More Careful Spectroscopic characterization
  and distinguish with the stellar-mass influence
  (i.e. update our preliminary analysis)
  - use archival spectral data in other sites?
- should be continue observations to detect Jupiter-analogs in order to compare with Jupiter-analogs’ occurrence.



add 1 data/month
over 0.5 yr