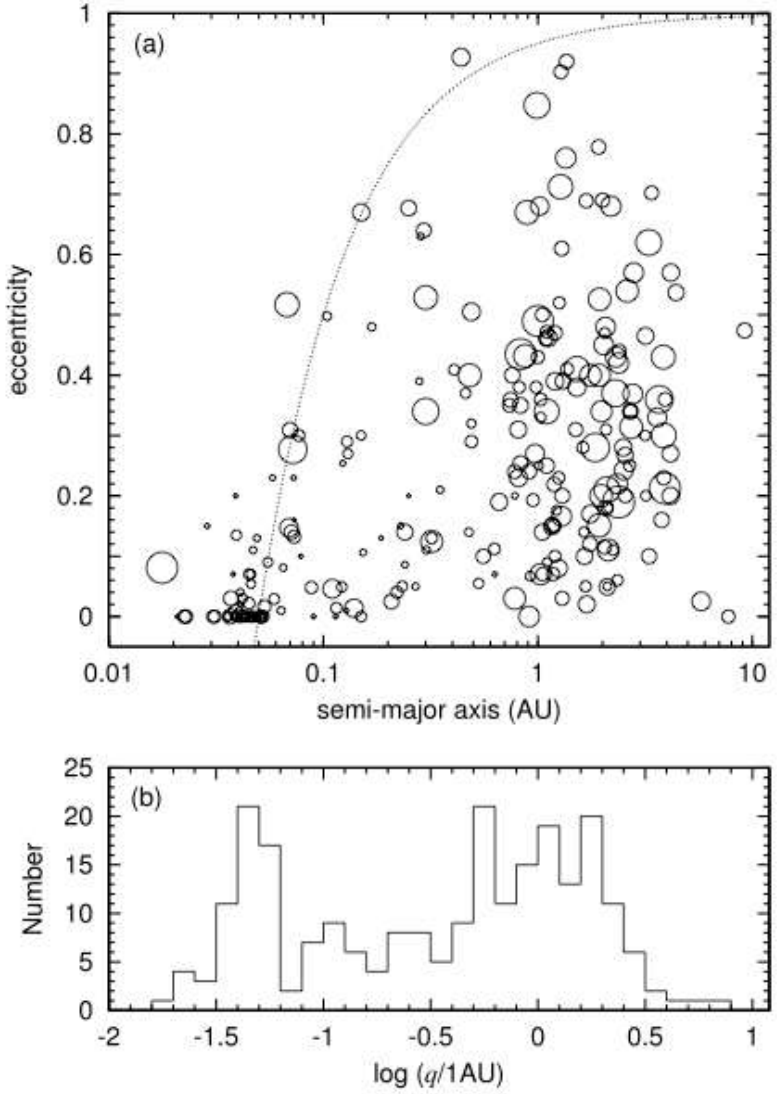
Australian National University

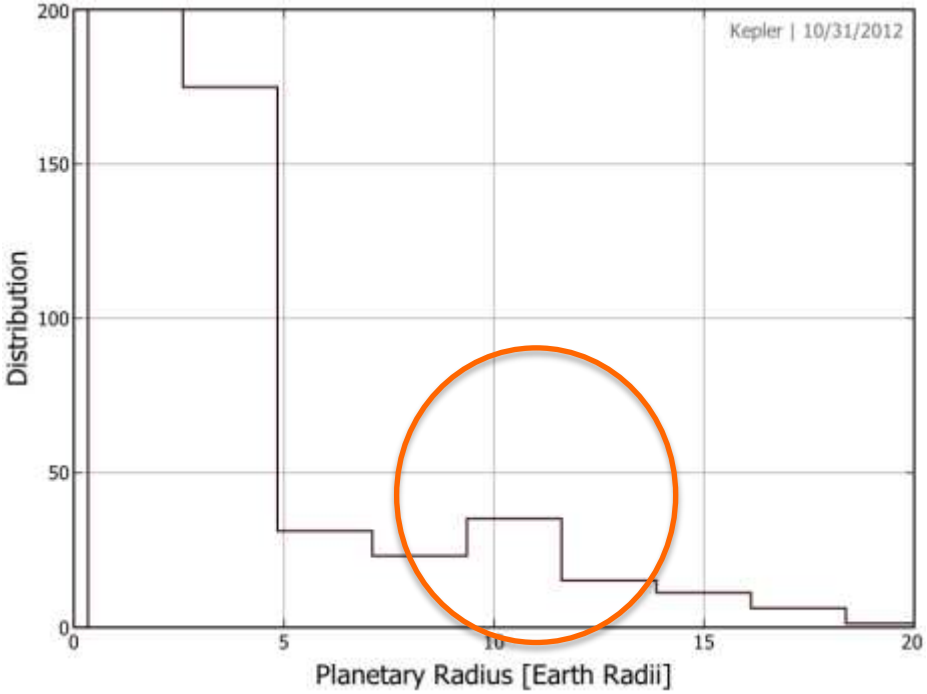
Skymapper and Kepler K2: Finding the Origin of Hot Gas Giants

Michael Ireland

(plus Adam Kraus, Kevin Covey… thanks to Mike Bessel, Dan Bayliss and others)

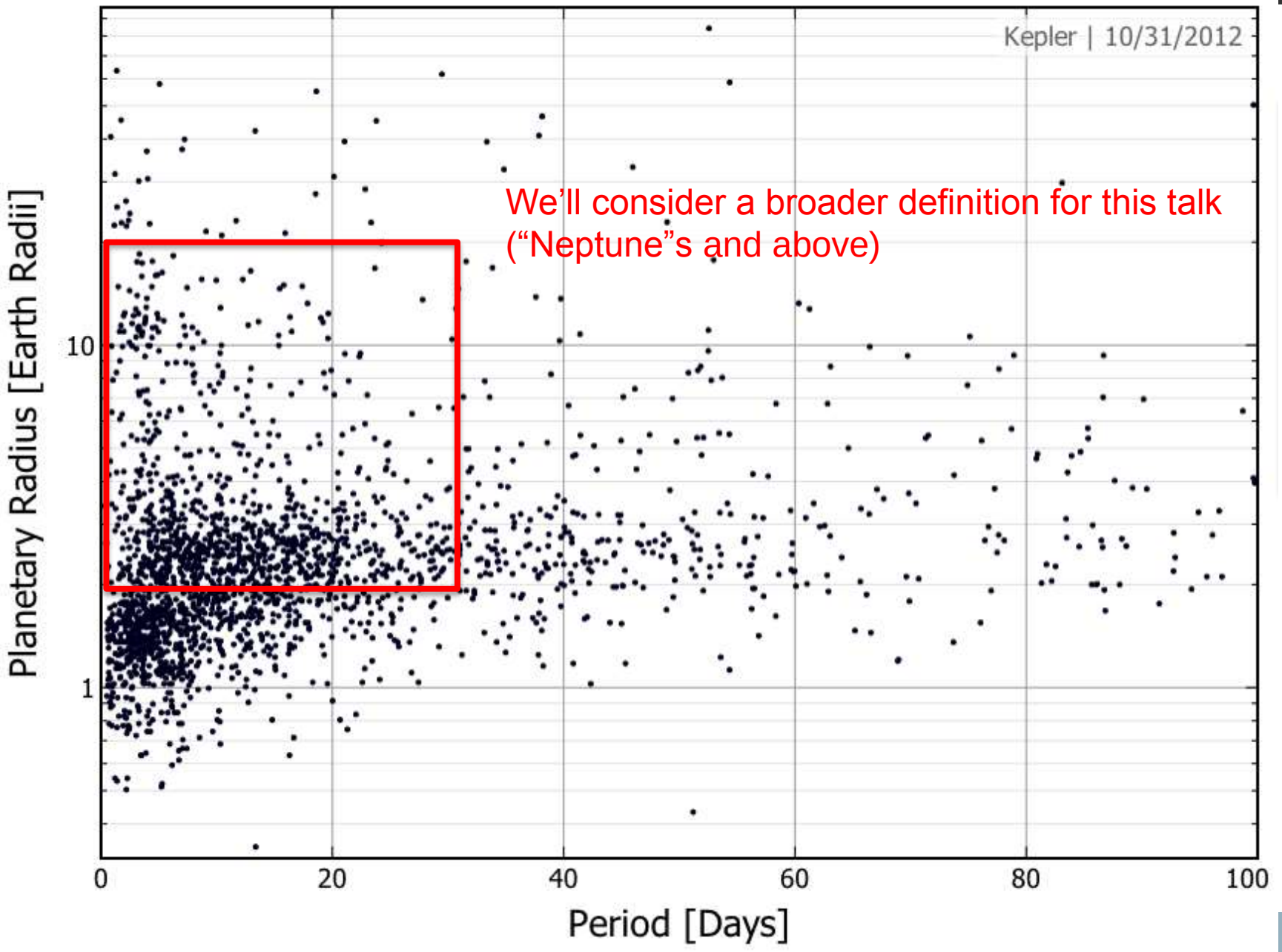
“Hot-Jupiters” are an observed distinct population



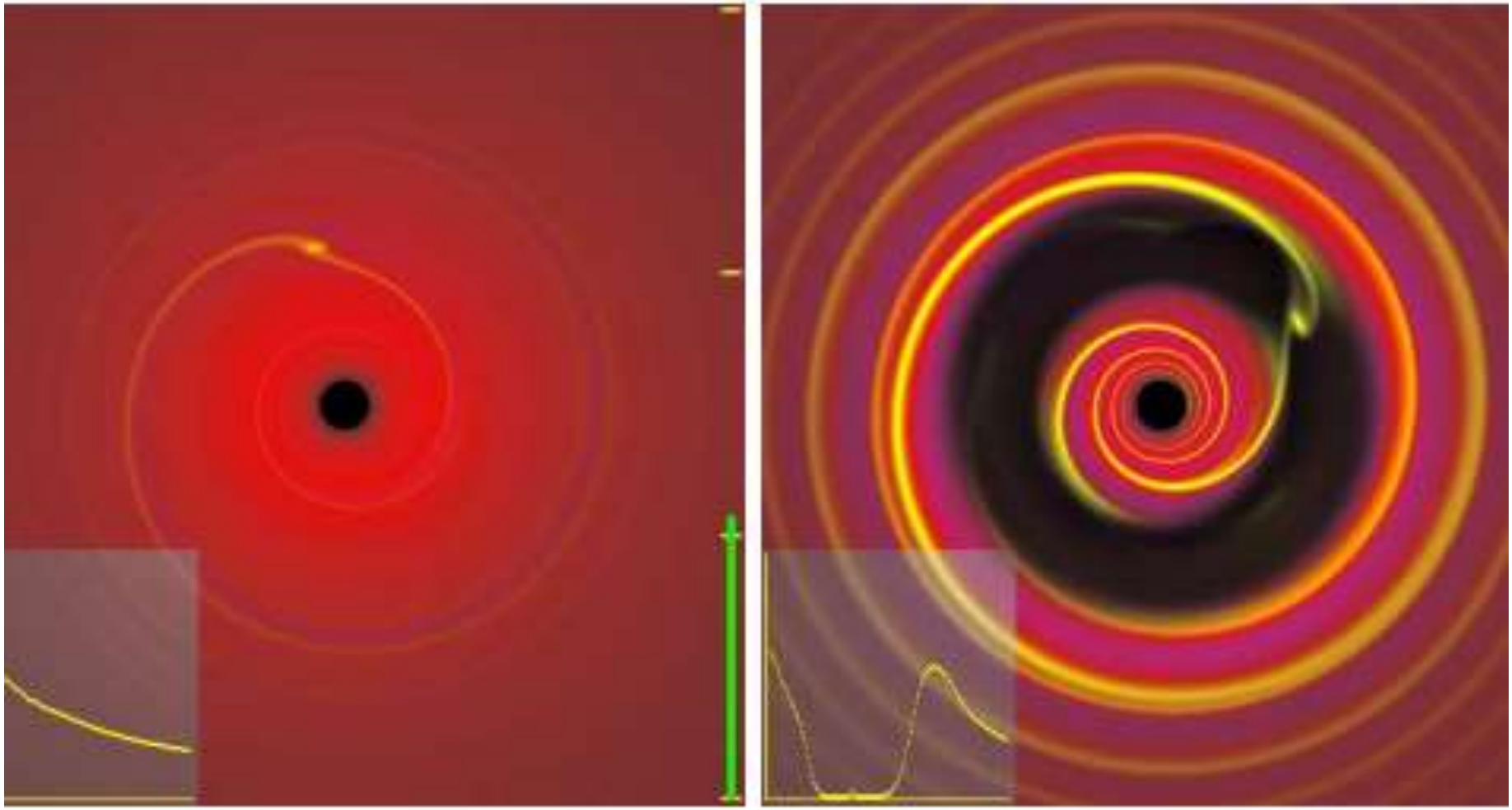


http://planetquest.jpl.nasa.gov/kepler/plots

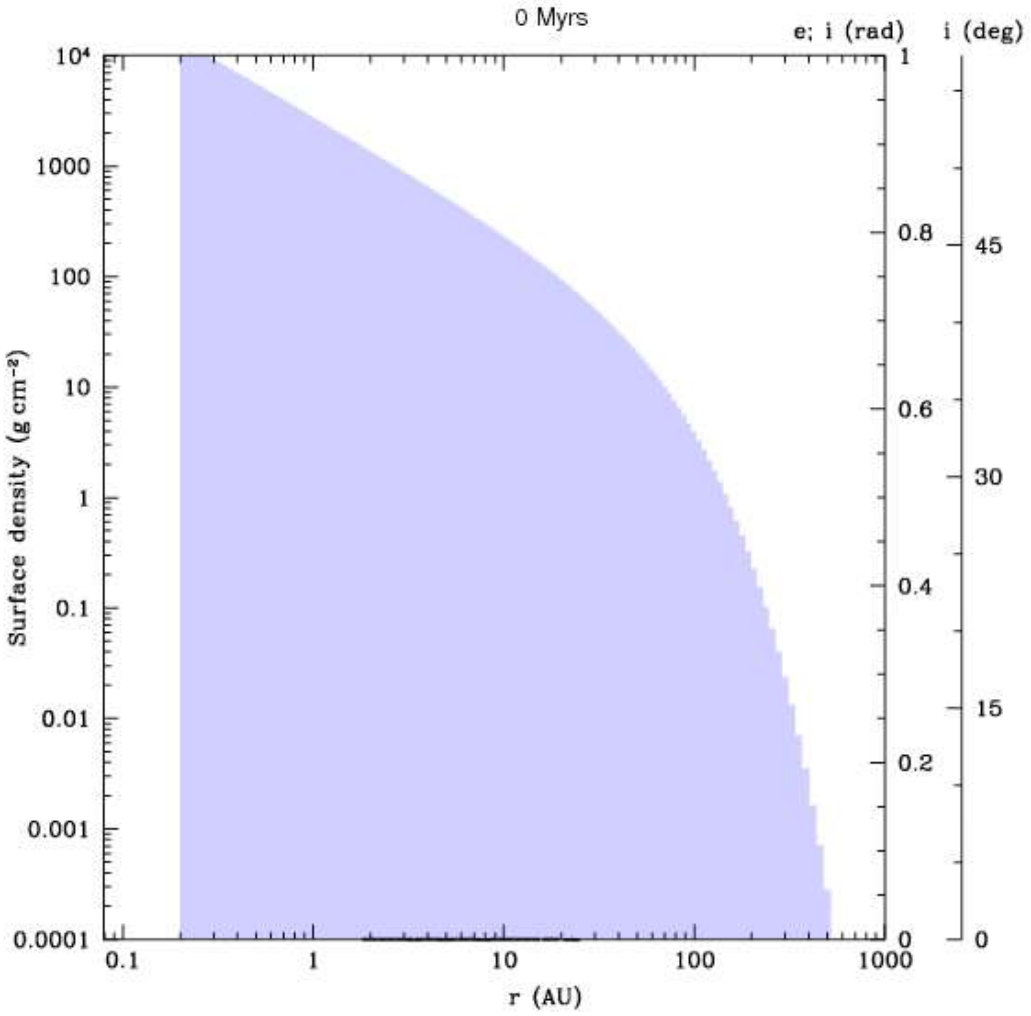
Nagasawa (2008)


Kepler | 10/31/2012
We'll consider a broader definition for this talk
("Neptune"s and above)
Planetary Radius [Earth Radii]
10
1
0
20
40
60
80
100
Period [Days]

Hot Jupiter Explanation: Migration



Hot Jupiter Explanation: Migration



Thommes et al (2008, Science): Planet formation with migraiton where one set of initial conditions gives the solar system and another gives a solitary hot Jupiter.

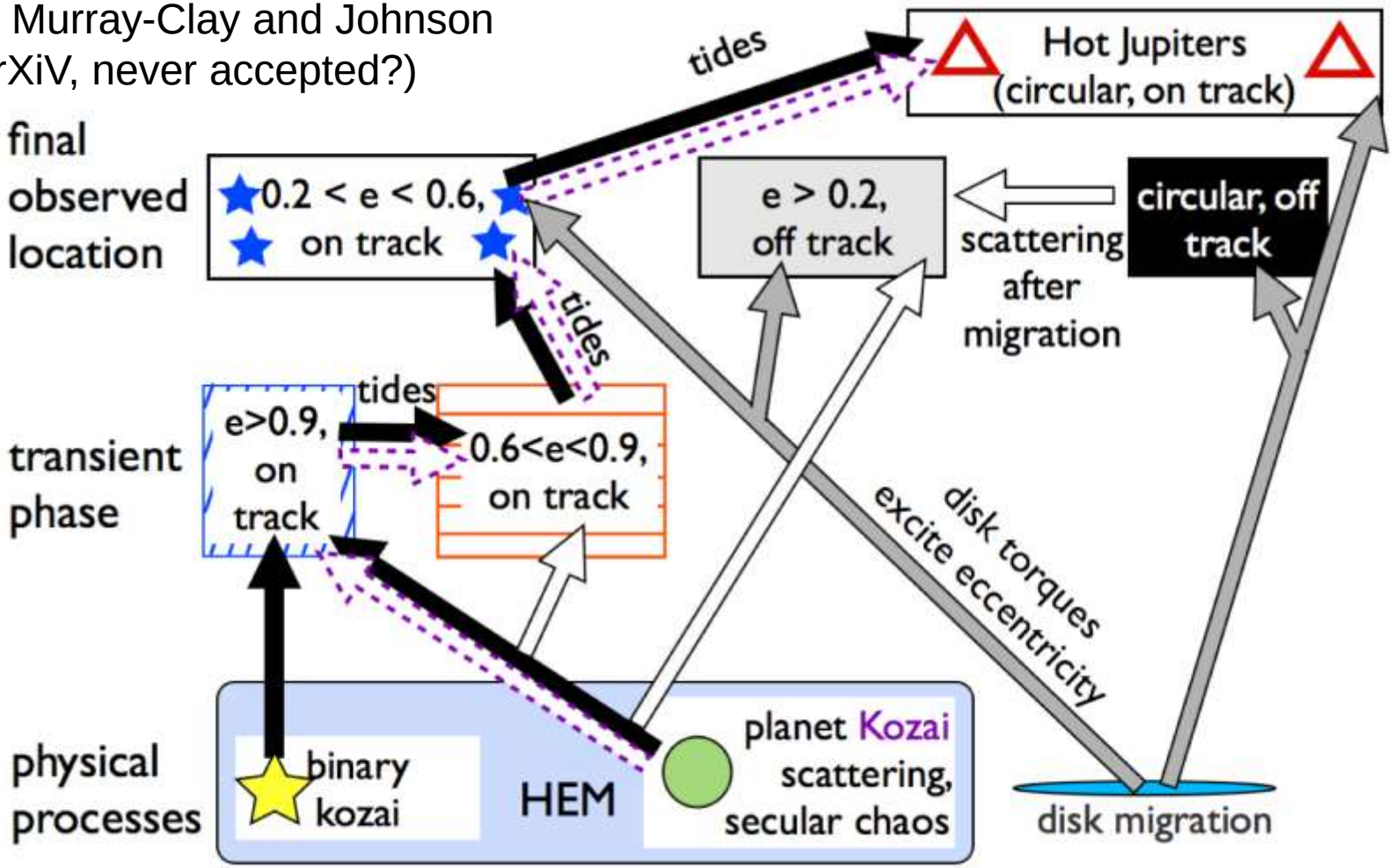
Hot Jupiters: Interactions and Kozai Resonances *after* disk dispersal

- Even relatively distant companions (low mass stars, massive planet) can pump inner orbits to high eccentricity.
- Works whenever initial mutual inclination is > 39°
- Stellar or planetary companions have the *same* total effect, but a planetary companion just takes longer to act.

(Tremaine lecture notes)

A complex, interesting picture…

Dawson, Murray-Clay and Johnson (2012, ArXiV, never accepted?)



Lots of Literature to-and-fro: we need *young star observations.*

Orbital migration of the planetary companion of 51 Pegasi to its present location

D. N. C. LIN*, P. BODENHEIMER* & D. C. RICHARDSON†

Title: Giant Extrasolar Planets? Jumping Jupiters!
Authors: Weidenschilling, S. J.; Marzari, F.

JUMPING JUPITERS IN BINARY STAR SYSTEMS

F. MARZARI

Stars Don't Eat Their Young Migrating Planets – Empirical Constraints On Planet Migration Halting Mechanisms

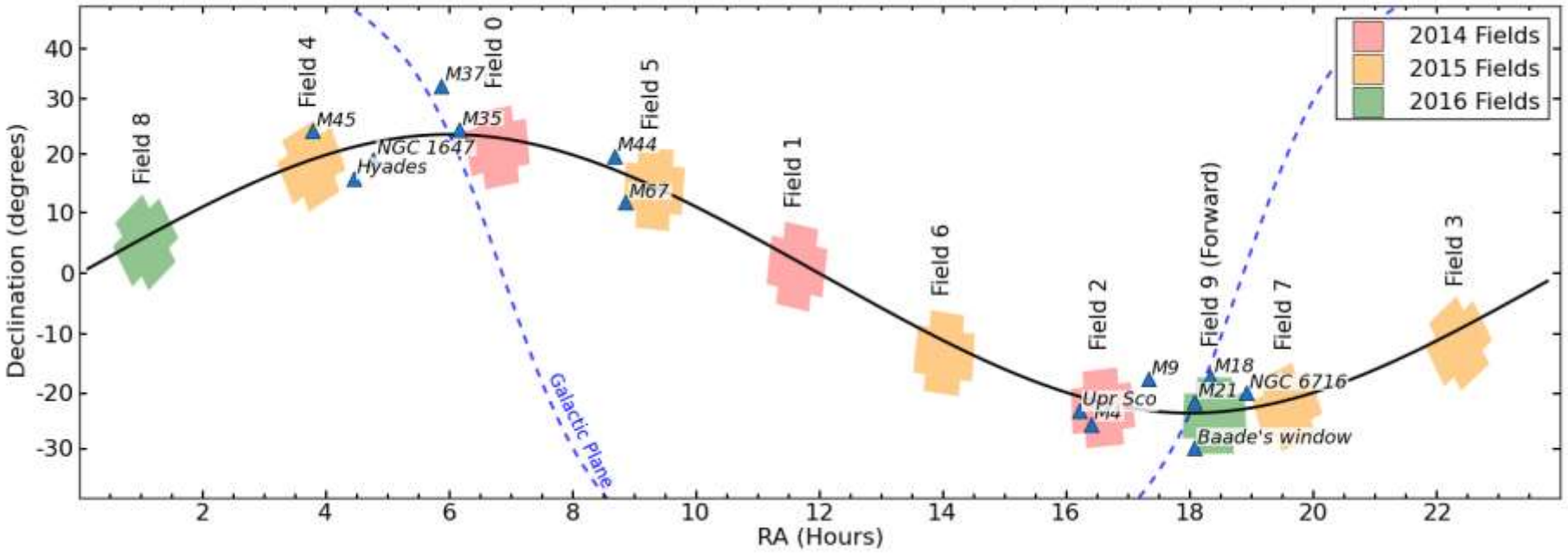
ON THE FORMATION OF HOT JUPITERS IN STELLAR BINARIES

SMADAR NAOZ,[1,2] WILL M. FARR,[2] AND FREDERIC A. RASIO[2,3]

FRIENDS OF HOT JUPITERS I: A RADIAL VELOCITY SEARCH FOR MASSIVE, LONG-PERIOD COMPANIONS TO CLOSE-IN GAS GIANT PLANETS

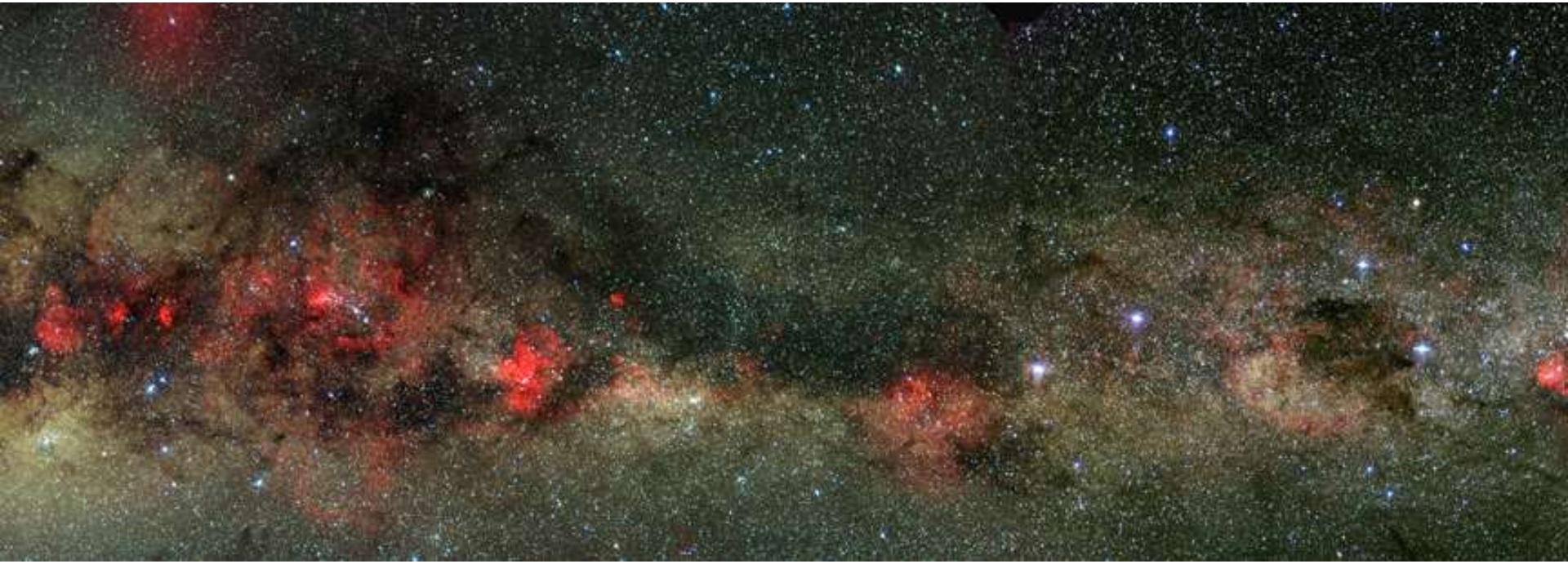
HEATHER A. KNUTSON[1,2], BENJAMIN J. FULTON[3], BENJAMIN T. MONTET[4,5], MELODIE KAO[4], HENRY NGO[1], ANDREW W.

Kepler Fields for the “K2” mission…



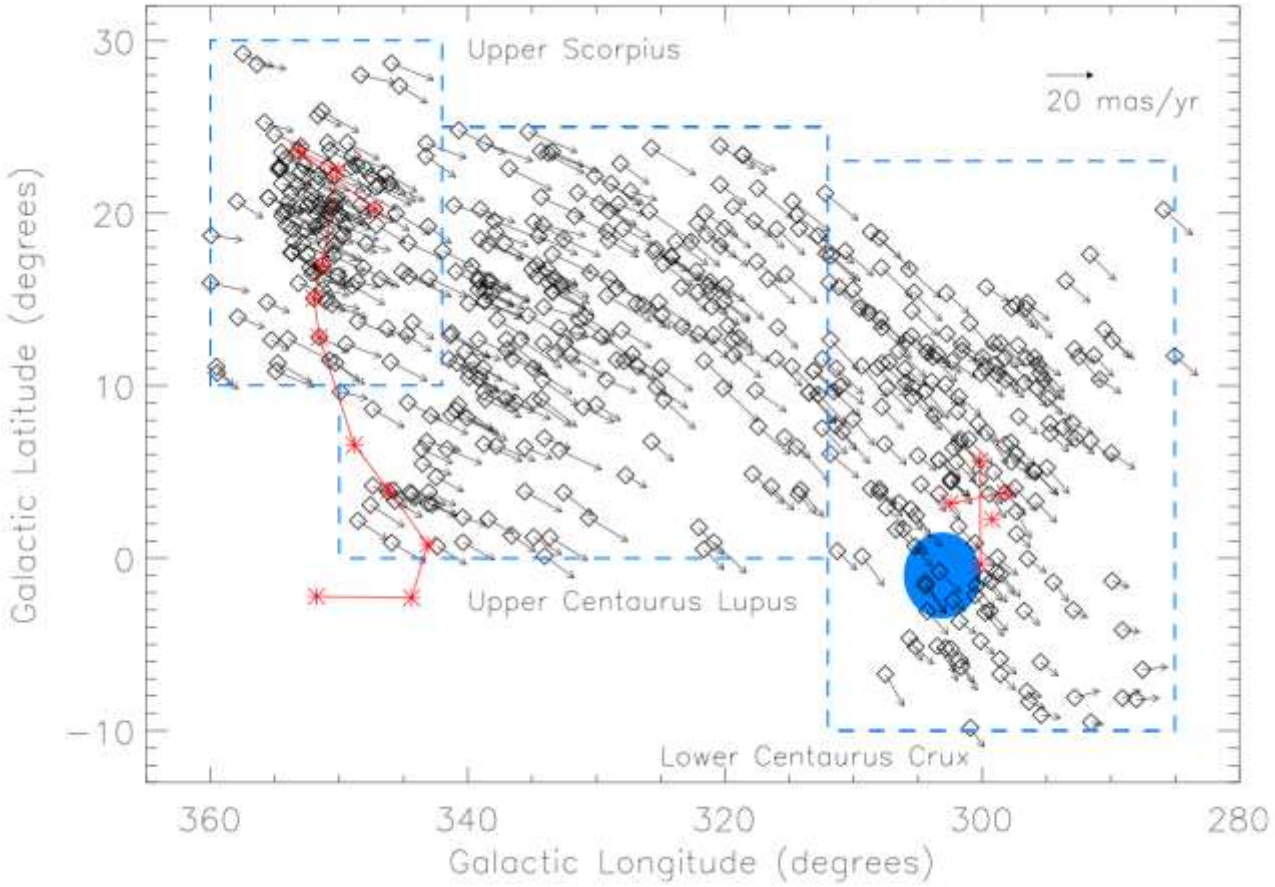
Field 2 is in Sco-Cen, including Upper Sco

Scorpius……..Lupus……Centaurus(pointers)……Southern Cross



Sco-Cen: The nearest association of young (~10 Myr), high mass stars at 100-200pc.

Field 2 is in Sco-Cen, including Upper Sco



Rizzuto, Ireland and Robertson (2011)

Bayesian Membership Selection

Ideally, finding members requires:

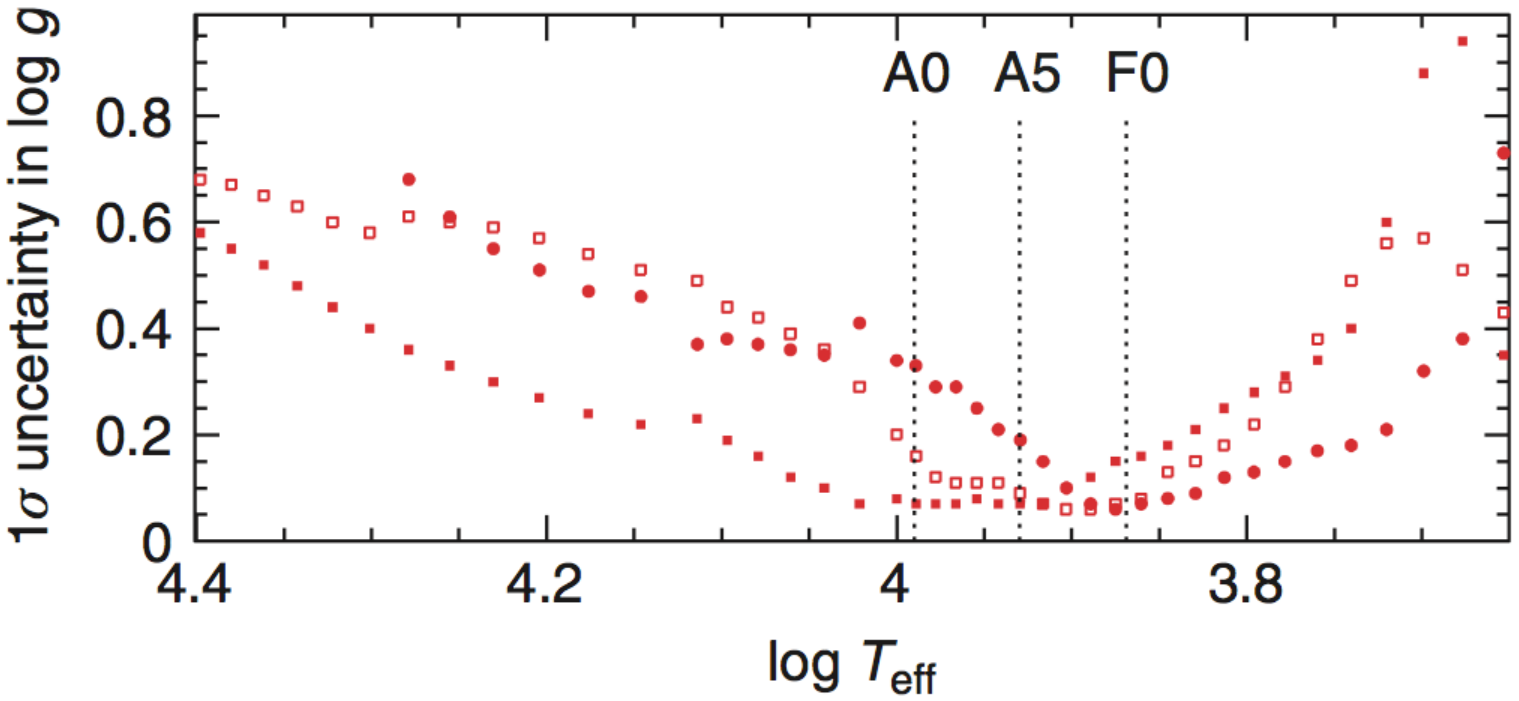
- Proper motion
- Spectroscopic Temperature and Bolometric flux
- Youth Indicators (e.g. Gravity or Lithium)
- Chemical tagging (at least metalicity)
- Parallax
- Radial velocity

Expected Number of Planets

- Based on ~1500 USco members (from ~3000 candidate young stars) we expect:
  - ~2 “Jupiters”
  - ~5 “Neptunes”
  - ~10 “Mini-Neptunes”

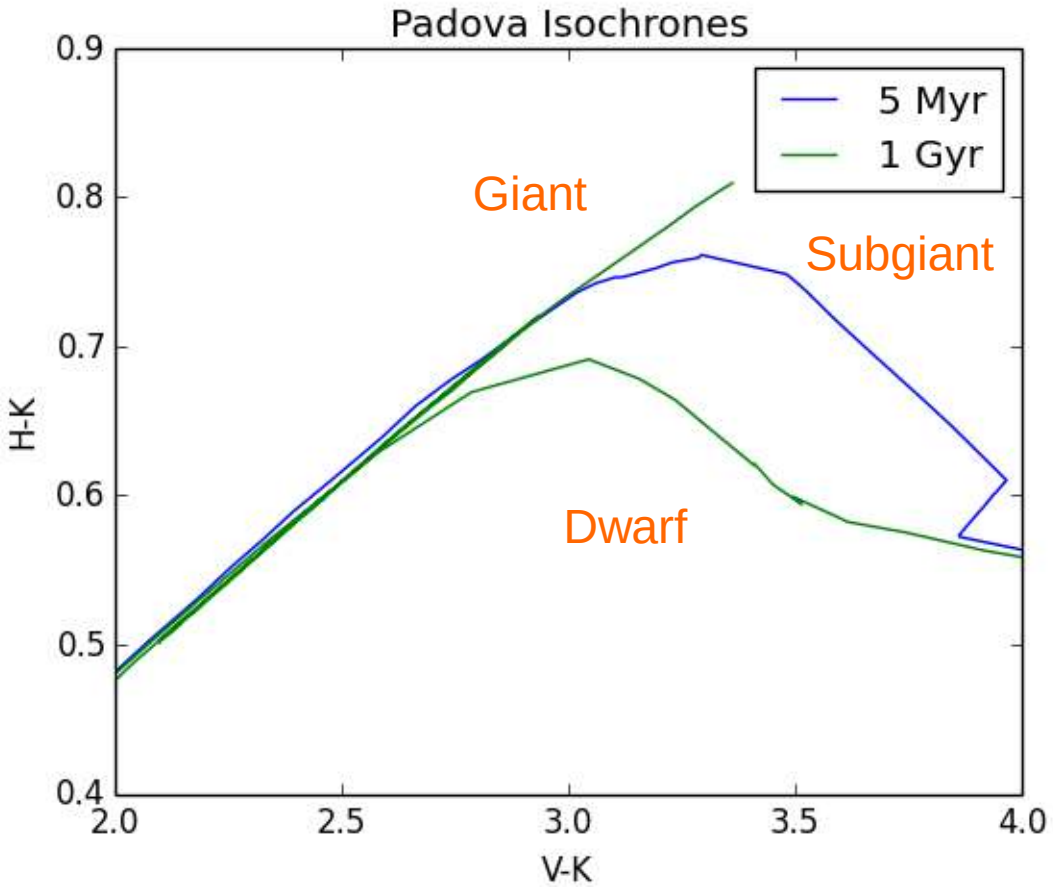
  (assuming planet frequency matches Howard 2011, some allowance for planetary inflation with “~”)
- Rho Ophiucus also probes the youngest ages, but with a smaller sample (~100s of stars)

Gravity from Skymapper

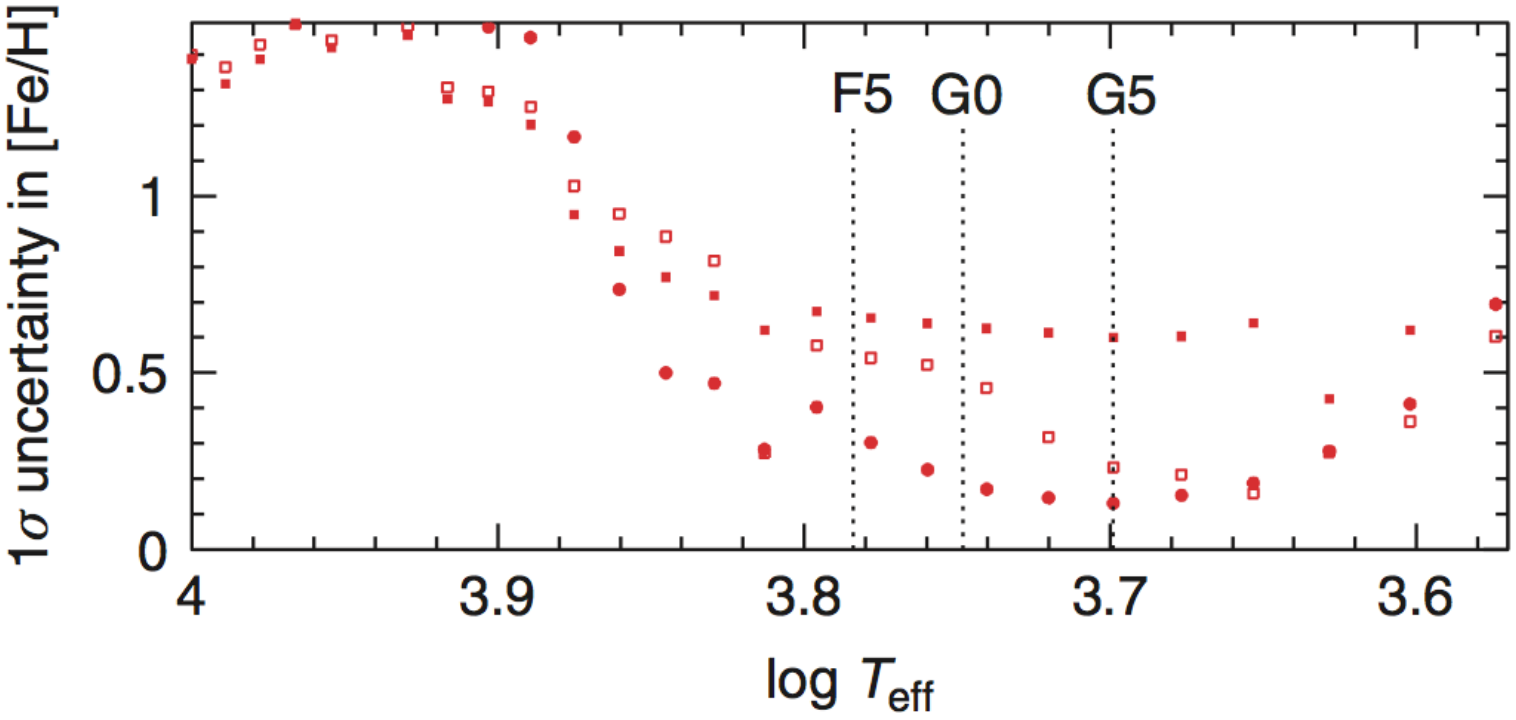


From Keller (2007) – gravity for F stars is easy. Lithium is typically a poor age indicator for these stars, but gravity is ~0.3 dex higher than the main sequence at 6300K (models at 5 Myr).

M Star Gravity from De-Reddened Colours



Metalicity from Skymapper



From Keller (2007) – metalicity determination enables a crude kind of “chemical tagging”, again improving membership probabilities.

Better Temperatures from Skymapper

- In the Bayesian membership selection, a distance comes from a HR diagram, and this has to match the proper motion amplitude for the association.
- Temperatures are critical for this, and relying on 2MASS is inadequate, especially around J-K=0.9.
- APASS is incomplete in this region (e.g. missing GSC 06214-00210) and as typical ~0.05 mag bright star errors.

Conclusions…

- Observations of young stars with the Kepler K2 mission
- Skymapper photometry (reduced collaboratively prior to K2 field 2 data availability) is needed to determine which stars are young.
- Data/pretty images prior to May 1 would really help the proposal for K2 targets!
- This is standard “fast” survey data.

Activity

- Stellar activity will influence the ability to discover “Neptunes”.
- This largely gives a periodic signal (with rotational period) even for very young stars (e.g. V410 Tau below)