Exocomets

B. Loibnegger

03.11.2016, Astrodynamic Seminar

Overview

- Comets in our Solar System
- Exocomets - "Short History"
- β Pictoris
- dynamical studies on HD10180

Artist's conception of β Pictoris
Credit: NASA / FUSE / Lynette Cook

Comets in our Solar System I

Comet Ison
Credit: Damian Peach, Oct. 11th, 2013

- small ($< 20km$ in diameter)
- ice, dust, frozen water, ammonia, carbon dioxide, carbon monoxide, methane
- source of comets:
  - **Kuiper-belt**: ring at $\sim 30 - 50$ AU
  - **Oort cloud**: sphere-like structure ($50.000 - 200.000$ AU)
  - Asteroid belt

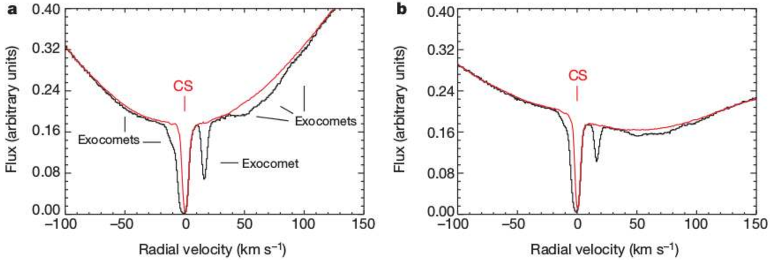
Comets in our Solar System II

- classification:
- short period comets ($p < 200$ yrs)
  - $p < 20$ yrs: Jupiter-family
  - $20 < p < 200$ yrs: Halley-type comets
- long period comets ($p > 200$ yrs)
- main-belt comets
- Sun-grazers

Comet Hyakutake, 1996
Credit:TAMDAS

Exocomets I

- First evidence for exocomets found in β Pictoris (1990, Beust et.al.)
- On short time scales varying absorption lines in spectra of β Pic (Ca II) with infall velocity $0 - 50\ kms^{-1}$ and terminal velocities sometimes reaching $300 - 400\ kms^{-1}$



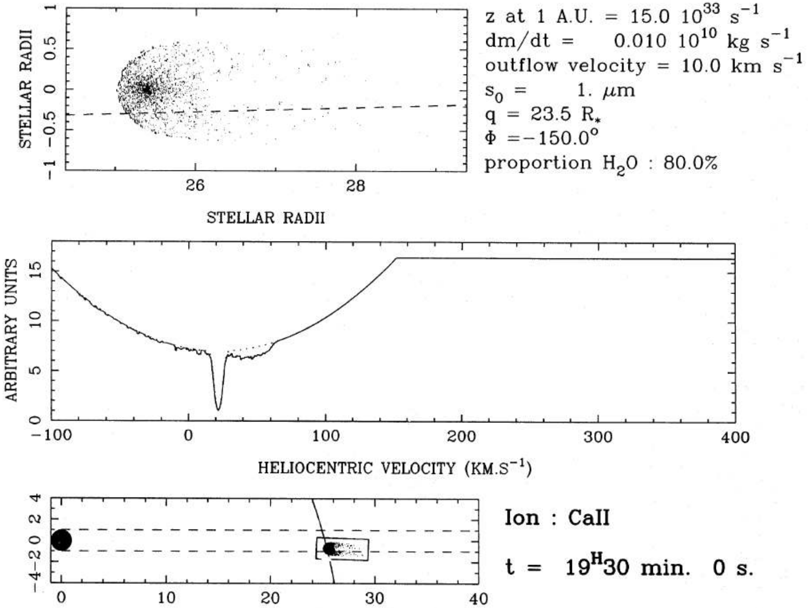
Kiefer et.al., 2014

Exocomets II

Beust et.al., 1990: 2D numerical simulations: absorption of gaseous cloud is computed and a synthetic spectrum is reproduced

- The model assumptions:
  - dust totally evaporated, when close enough to star
  - comets coming from circumstellar disk $\rightarrow$ parabolic orbit close to star
  - dust production rate constant and isotropic for nucleus
  - size of dust grains: 1 μm
- **Results:**
  - Observations could be reproduced
  - infalling bodies have to come from $\Phi \sim 150^\circ$ (line between axis of orbit and line of sight)
  - No CaII absorption component produced closer than $\sim 10 - 15 R_\star$ (radiation pressure)

Exocomets III



Dynamical work on β Pictoris:
Beust & Morbidelli, 1996

- propose: mean-motion resonances with a massive planet on moderately eccentric orbit
- 4:1 or 3:1 resonance with planet with $e \geqslant 0.05$

- Planet β Pic b found in 2008:

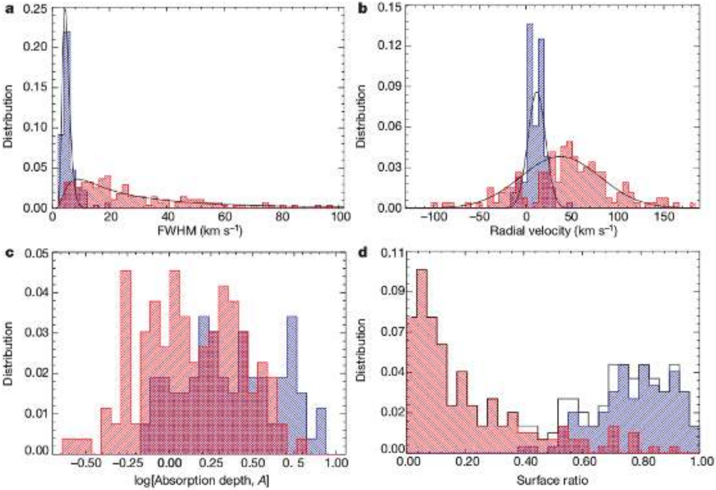
Planet	Mass (M_{Jup})	Radius (R_{Jup})	Period (day)	a (AU)	e	i (deg)	Ang. dist. (arcsec)	Discovery	Update
beta Pic b	7	1.65	13288	13.18	0.323	89.01	0.440415	2008	2016-02-16

Showing 1 to 1 of 1 entries

First Previous 1 Next Last

`www.exoplanet.eu`

Two families of exocomets in β Pictoris



Kiefer et.al.,2014

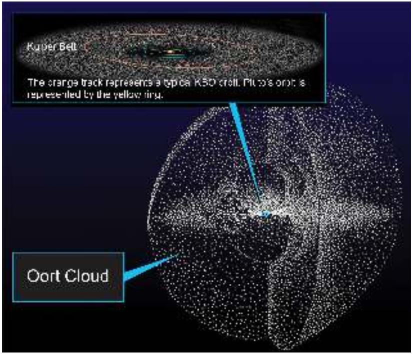
Population S:

- broad distribution of radial velocities: $36 \pm 55 kms^{-1}$
- broad distribution in FWHM
- small surface ratio
- orbits close to star: $d \sim 10 \pm 3R_{\star}$
- less active

Population D:

- narrow distribution of radial velocities: $15 \pm 6 kms^{-1}$
- peaked distribution in FWHM
- large surface ratio
- orbits at wider distances: $d \sim 19 \pm 4R_{\star}$
- active surfaces
- larger periastron distances and narrow range of longitudes indicates they share similar orbit and may result from breakup of bigger body

Exocomets in other star systems: I



Credit: NASA

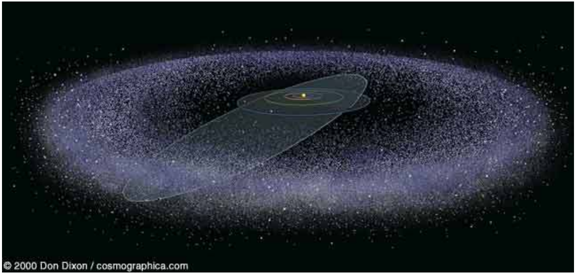
- varying absorption features with $\pm 100 kms^{-1}$ in HD21620, HD110411, HD42111, HD145964 (all $< 5 Myrs$ old) (Welsh & Montgomery, 2013)
- 22 exo-Kuiper-belt candidates found in exo-systems: "Leftover planetesimal belts are common" (Nilsson, 2010)

- Dust has a limited lifetime $\rightarrow$ asteroidal and/or cometary bodies continuously renew the amount of dust and form dusty debris disks (Welsh & Montgomery, 2013)

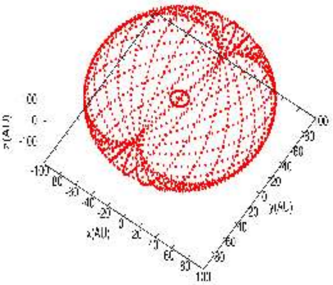
Exocomets in other star systems: II

- Stars form in clusters → Sun captured comets from other stars
  - a substantial fraction of Oort cloud comets (perhaps $> 90\%$) are from the protoplanetary disks of other stars

(Levison et.al, 2010)



Dynamical Work on HD10180 I



Setup:

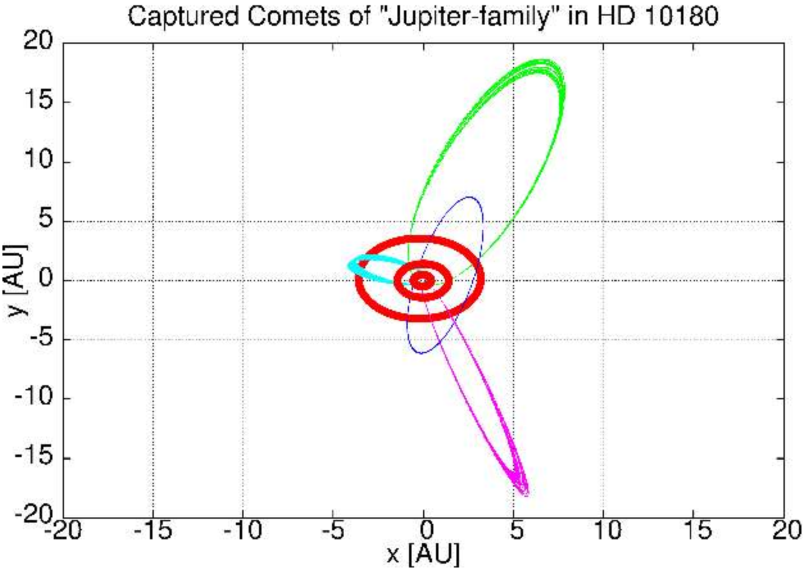
- comets distributed on a sphere: $0^\circ < i < 180^\circ$, $0^\circ < \Phi < 360^\circ$
- eccentricity: $0.95 < e < 0.99$
- integrations for different initial semi-major axes in the range of $90AU - 150AU$

Planet	Mass (M_{Jup})	Radius (R_{Jup})	Period (day)	a (AU)	e	i (deg)	Ang. dist. (arcsec)	Discovery	Update
HD 10180 c	0.041217	—	5.75979	0.0641	0.045	—	0.001627	2010	2012-01-31
HD 10180 d	0.03696945	—	16.3579	0.1286	0.088	—	0.003264	2010	2012-01-31
HD 10180 e	0.07897304	—	49.745	0.2699	0.026	—	0.00685	2010	2012-01-31
HD 10180 f	0.07519743	—	122.76	0.4929	0.135	—	0.01251	2010	2012-01-31
HD 10180 g	0.06733159	—	601.2	1.422	0.19	—	0.036091	2010	2010-12-07
HD 10180 h	0.202624	—	2222	3.4	0.08	—	0.086294	2010	2010-12-07

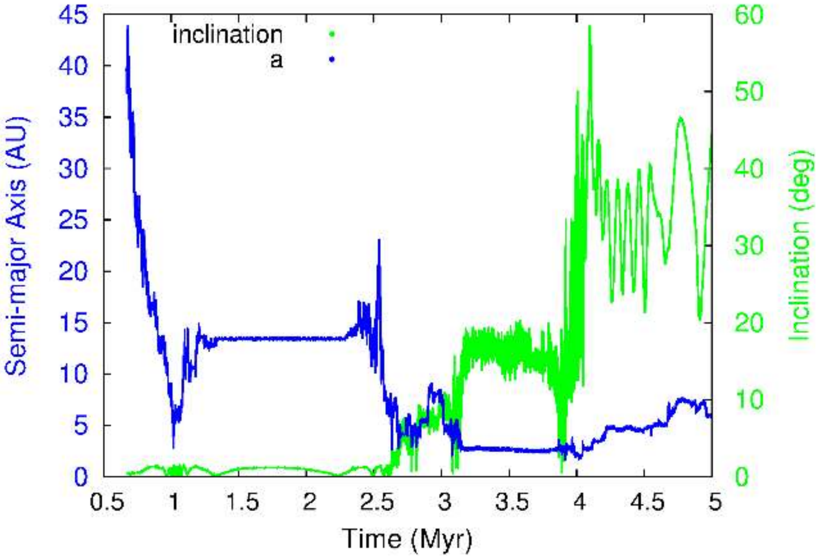
Showing 1 to 6 of 6 entries

First Previous 1 Next Last

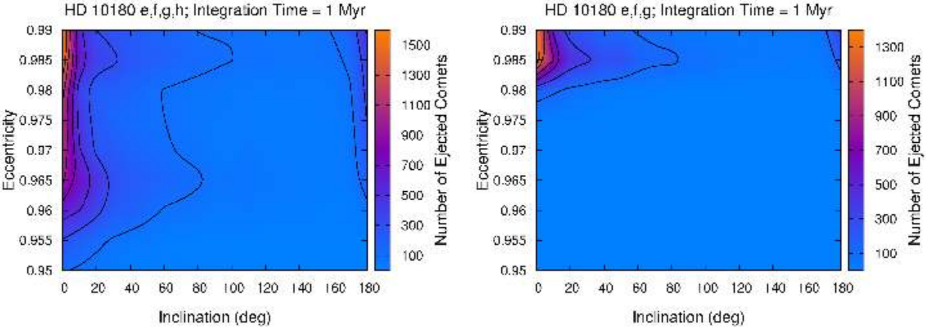
Dynamical Work on HD10180 II



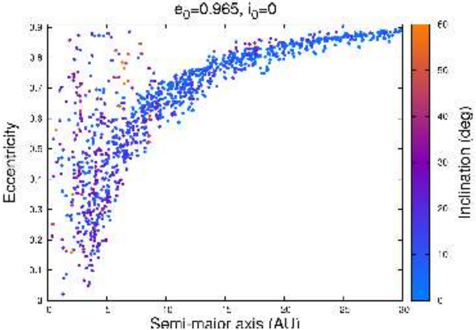
Dynamical Work on HD10180 III

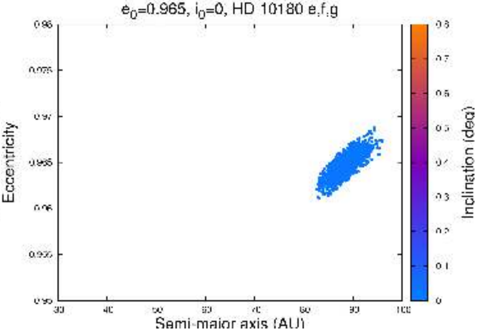


Dynamical Work on HD10180 IV



Dynamical Work on HD10180 V





Summary and Conclusions

- There exist comets in other planetary systems.
  - Leftovers from planetformation
  - They continuously renew the amount of dust
- There exist families of comets (e.g. β Pictoris)
- Dynamically:
  - From orbits of comets $\rightarrow$propose planets (mean-motion resonances)
  - Capture of comets on stable orbits is possible
  - We need a massive planet to capture comets

Thanks for your attention!

C/2014 Q1 (Pan-STARRS), Photo by Yuri Beletsky