Asteroid taxonomy using Python

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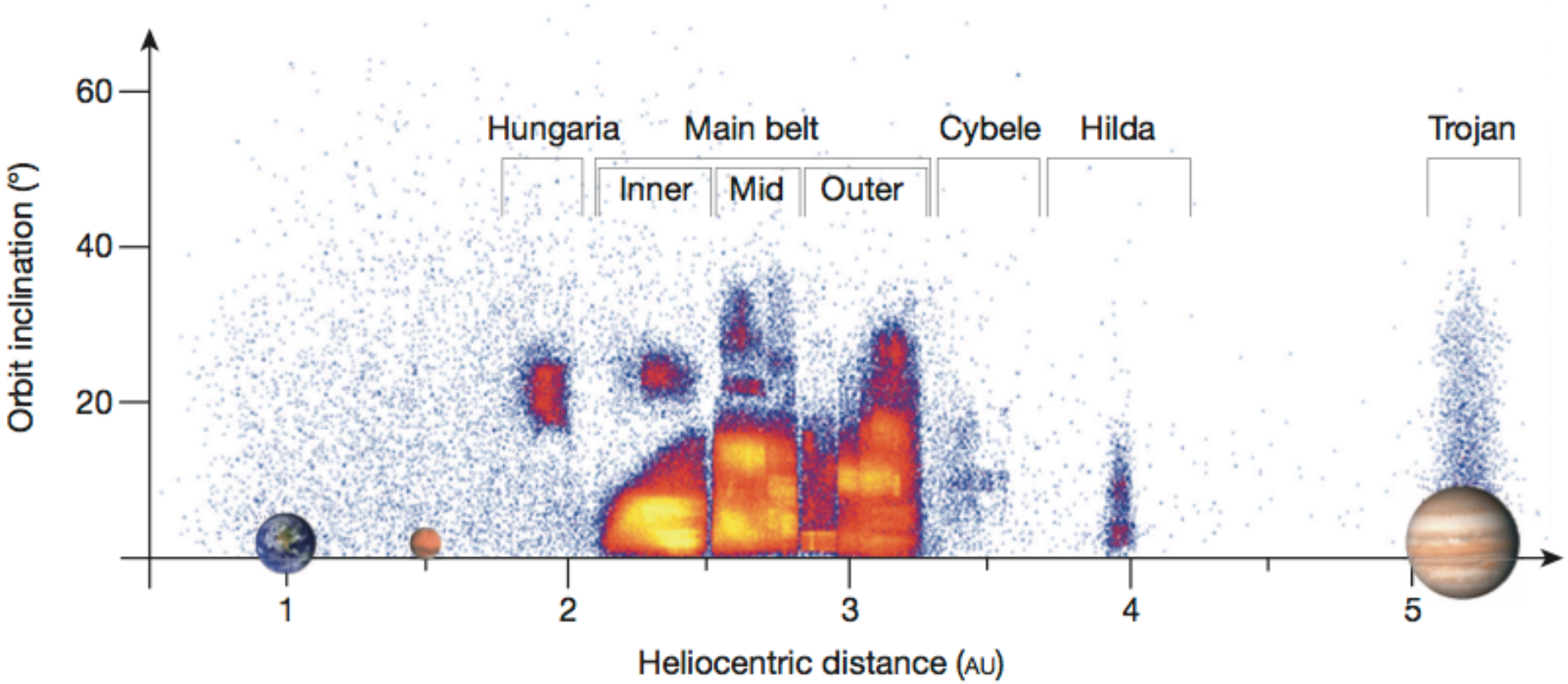
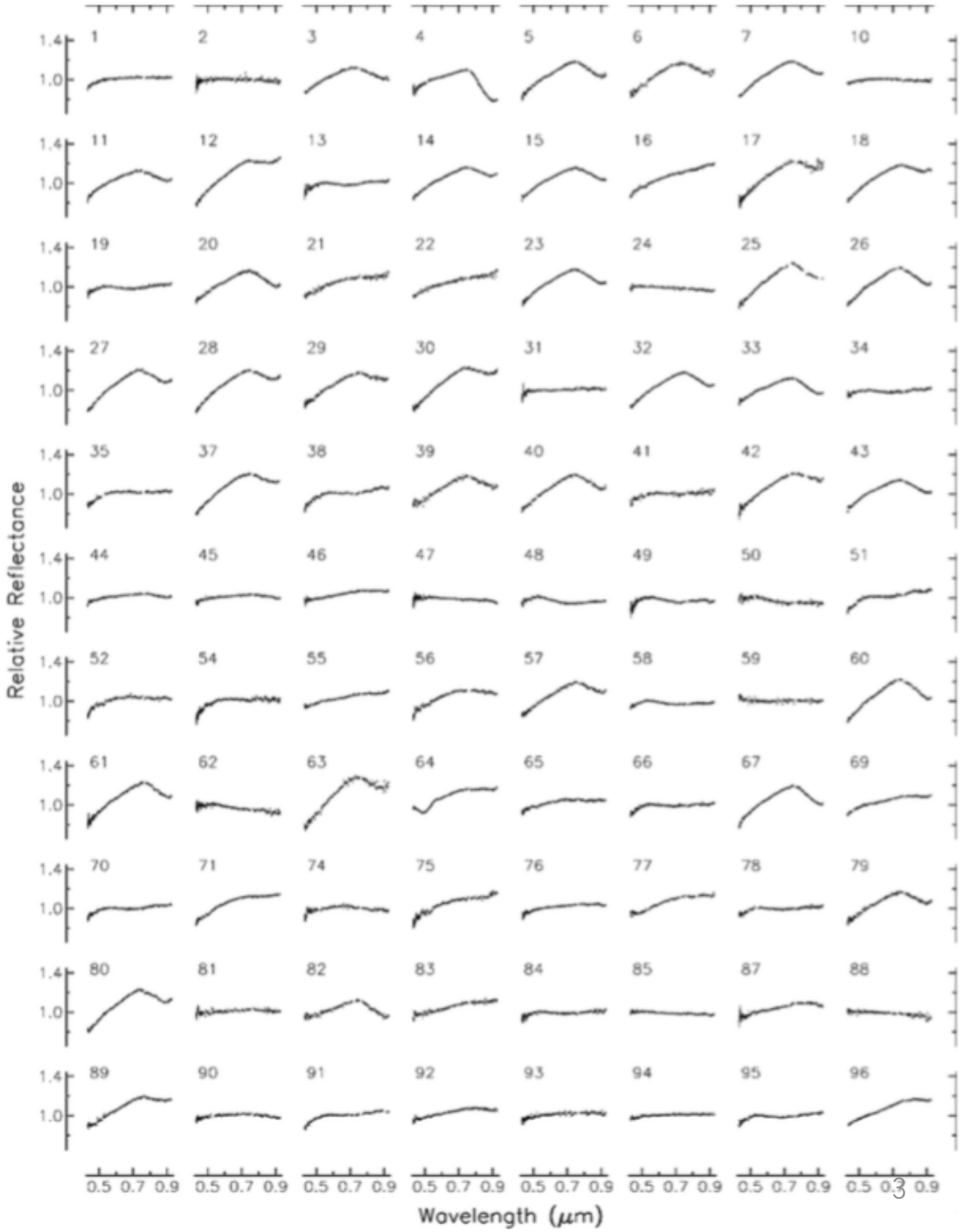
Main Asteroid Belt



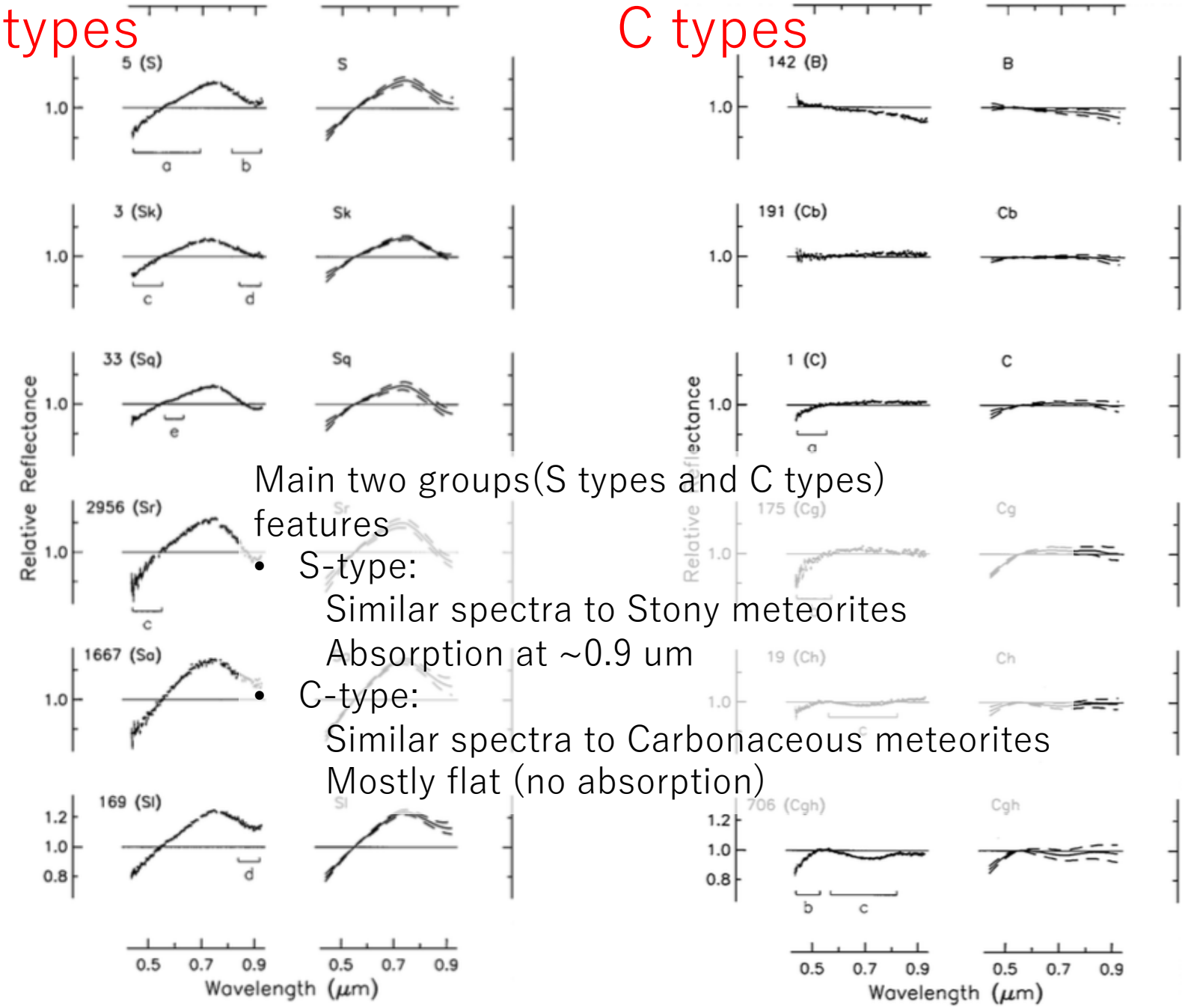
DeMeo & Carry (2014) Nature

Visible spectra of asteroids
Bus & Binzel (2002) Icarus



S types

C types

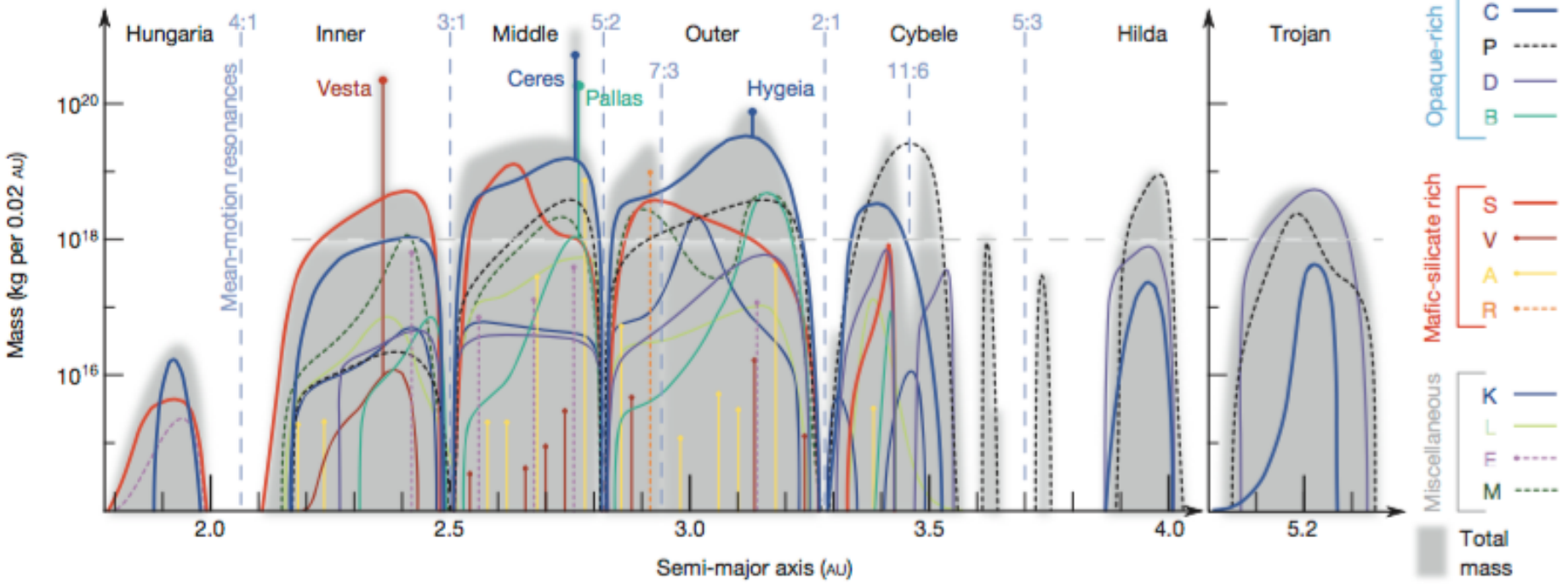


Main two groups(S types and C types) features

- S-type:
  Similar spectra to Stony meteorites
  Absorption at ~0.9 um
- C-type:
  Similar spectra to Carbonaceous meteorites
  Mostly flat (no absorption)

Bus & Binzel (2002) Icarus

Orbital distance and spectra



DeMeo & Carry (2014) Nature

- The meaning of asteroid spectra distribution has not been fully understood yet.
  - Grand Tack? Gravitational instability?
  - Gradual mixing

-> Understanding the variation and categorization of spectra is important.

Today's agenda

- plotting
- categorize asteroid spectra automatically
  - Principal component analysis
  - K-means

Principal Component Analysis（PCA）

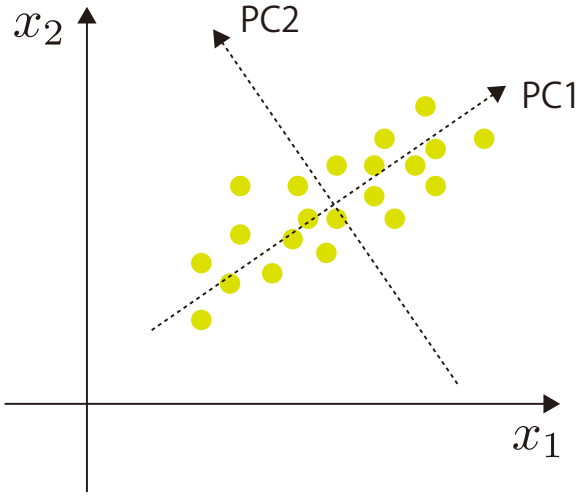
An orthogonal transformation to obtain the principal spectral components.

- The first principal component (PC1) has the largest variance.
- The second principal component (PC2) has the largest variance under constrain that it is orthogonal to the PC1. (repeat the same for other PCs)
- Small number of components with large eigenvalues can account for the principal characteristics of observational data.

$$\boldsymbol{X} = \boldsymbol{Y} = \begin{bmatrix} \text{PC1 score} \\ \text{PC2 score} \\ \vdots \\ \text{PC}N\text{ score} \end{bmatrix}$$

$$\begin{bmatrix} \overrightarrow{\text{PC1}} \\ \overrightarrow{\text{PC2}} \\ \vdots \\ \overrightarrow{\text{PC}N} \end{bmatrix}$$

PCs

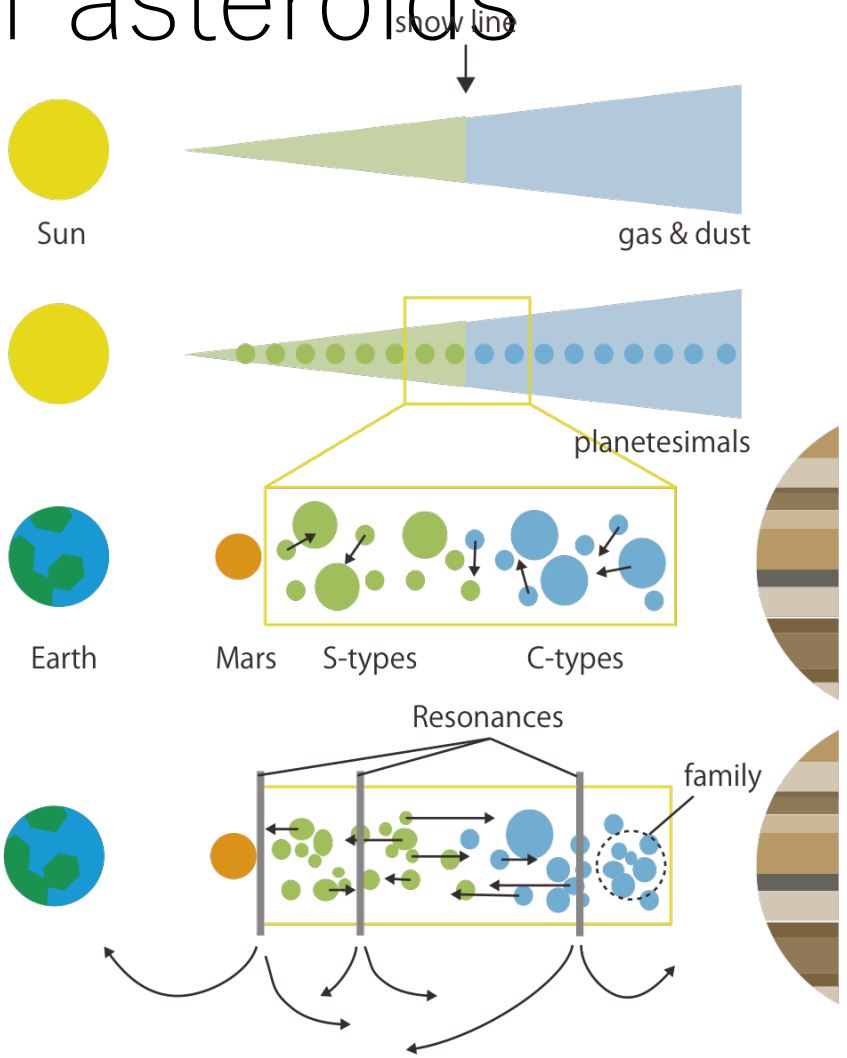


X: Observations (Discrete local spectra), Y: PC scores

Orbital evolution of asteroids

Steady state

1. Asteroids are repeatedly disrupted by impacts each other and get smaller and smaller.
2. Yarkovsky effect influence the smaller asteroid orbits. Smaller could be moved faster. *Bottke et al. (2001)*
3. Once asteroids reach to resonances, they are swiftly removed from the main belt.



Small asteroids could control the mass flux to the inner Solar System!

Surface condition of small asteroids can influence orbital evolution rate through Yarkovsky and YORP effect.