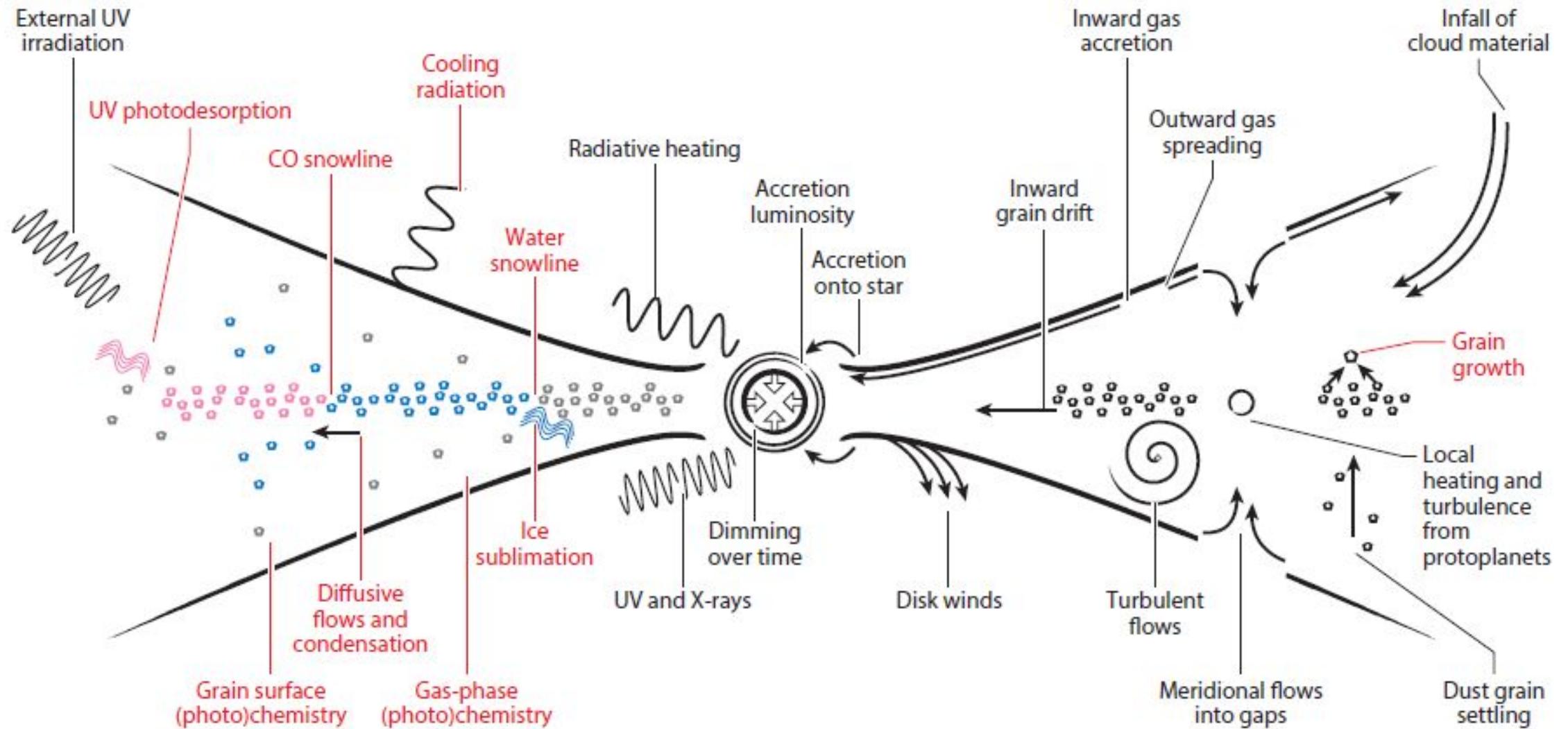
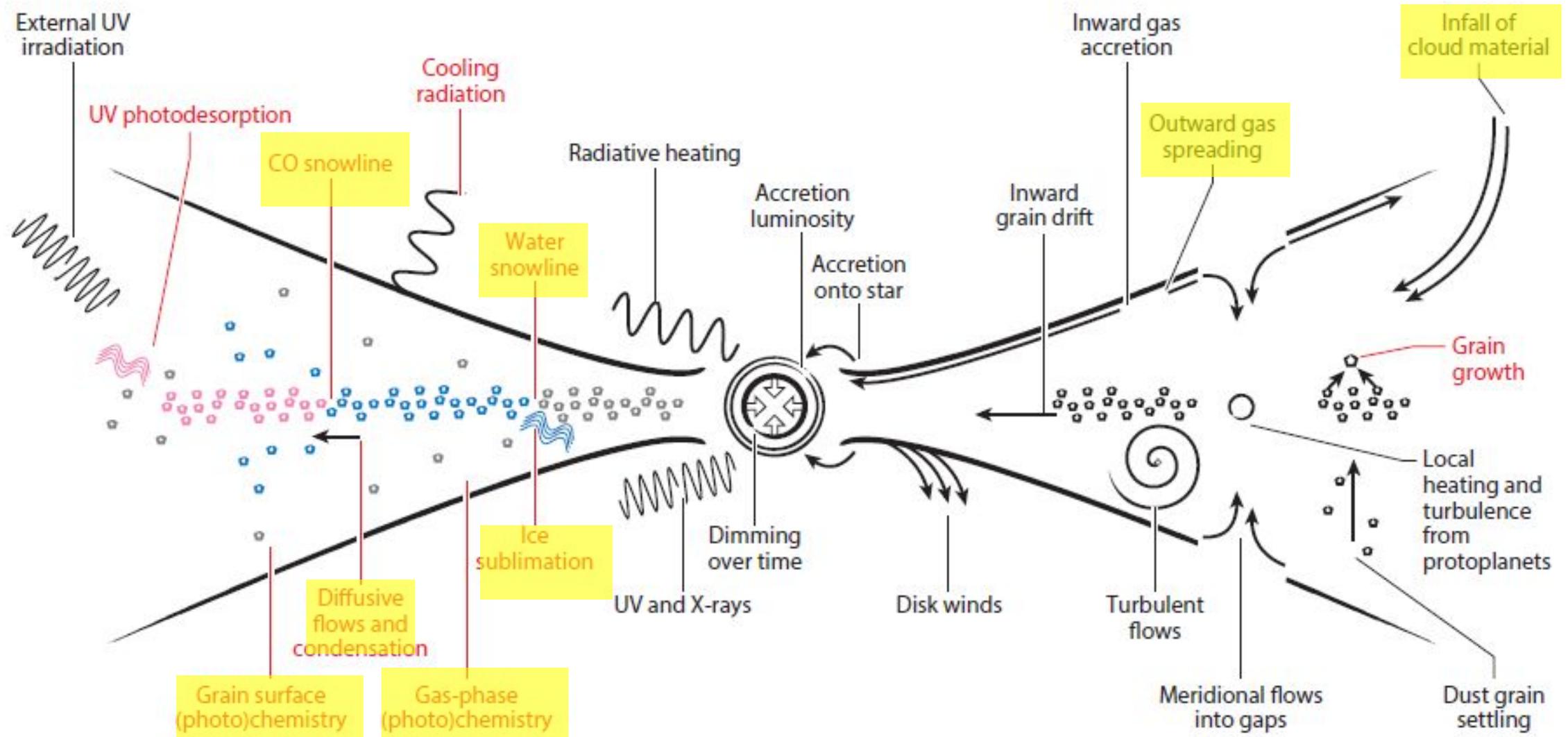


# Ices in the outer solar system and their connection to the protoplanetary disk

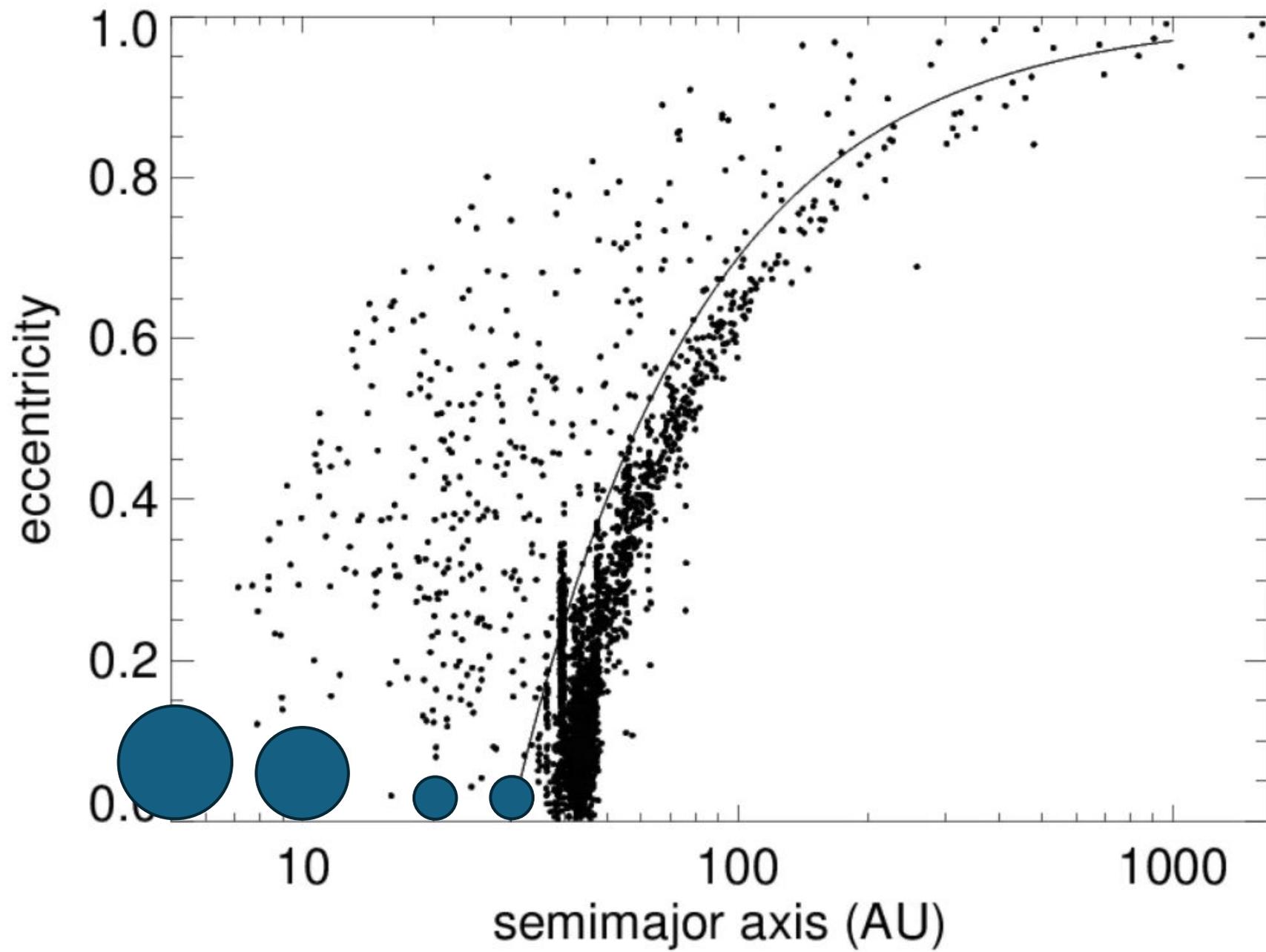
Mike Brown  
Caltech

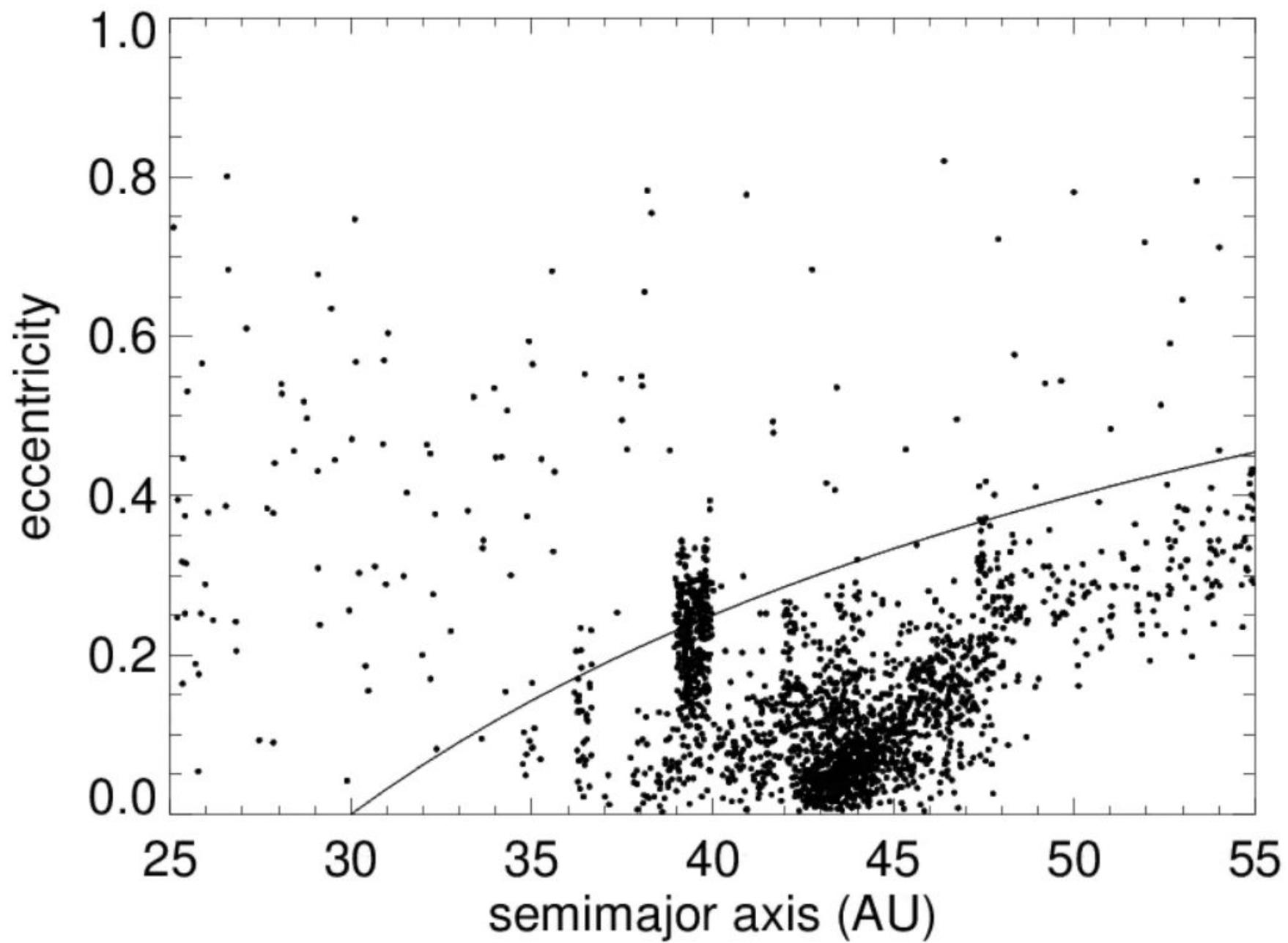


- |                                    |                                     |
|------------------------------------|-------------------------------------|
| Disk and stellar dynamic processes | ◊ Bare silicate grains              |
| Chemical processes                 | ◈ Water ice-dominated grains        |
|                                    | ◉ Hypervolatile CO-dominated grains |

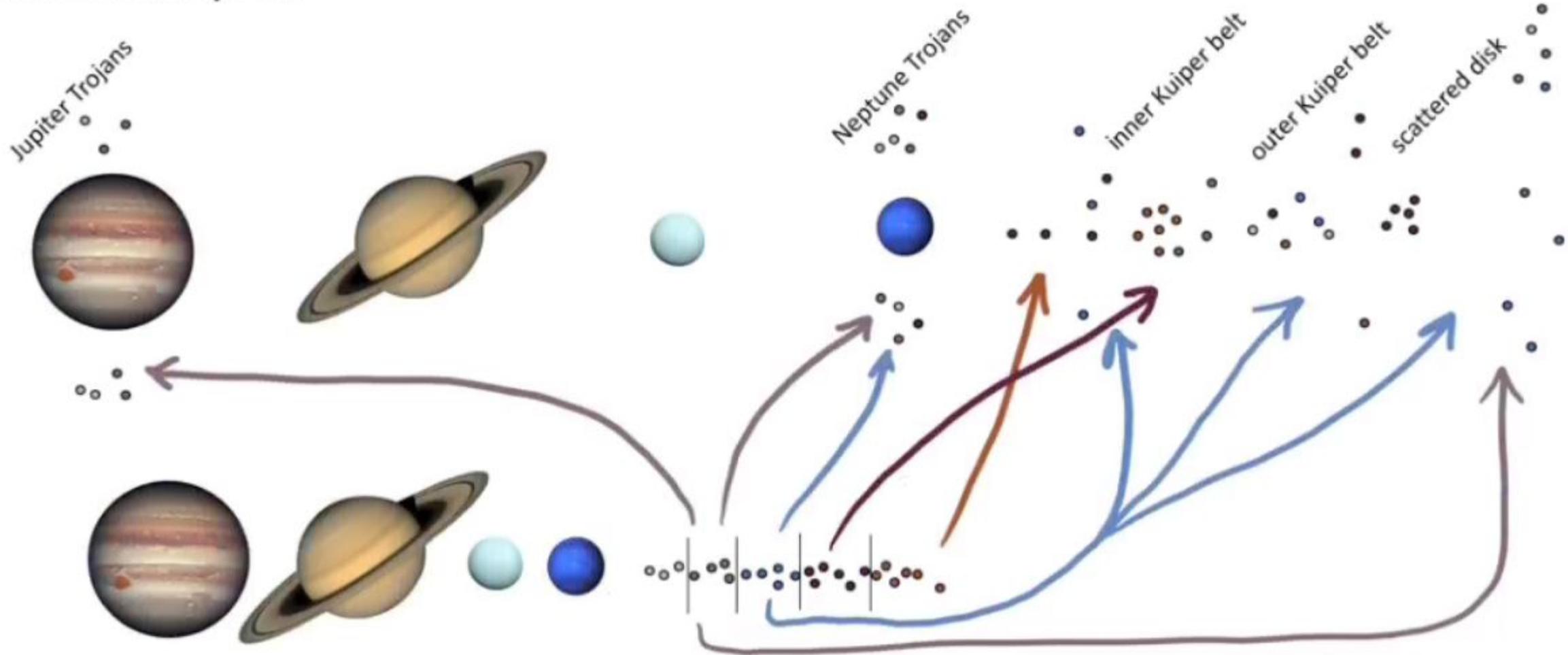


- |                                    |                                     |
|------------------------------------|-------------------------------------|
| Disk and stellar dynamic processes | ⬠ Bare silicate grains              |
| Chemical processes                 | ⬡ Water ice-dominated grains        |
|                                    | ⬢ Hypervolatile CO-dominated grains |



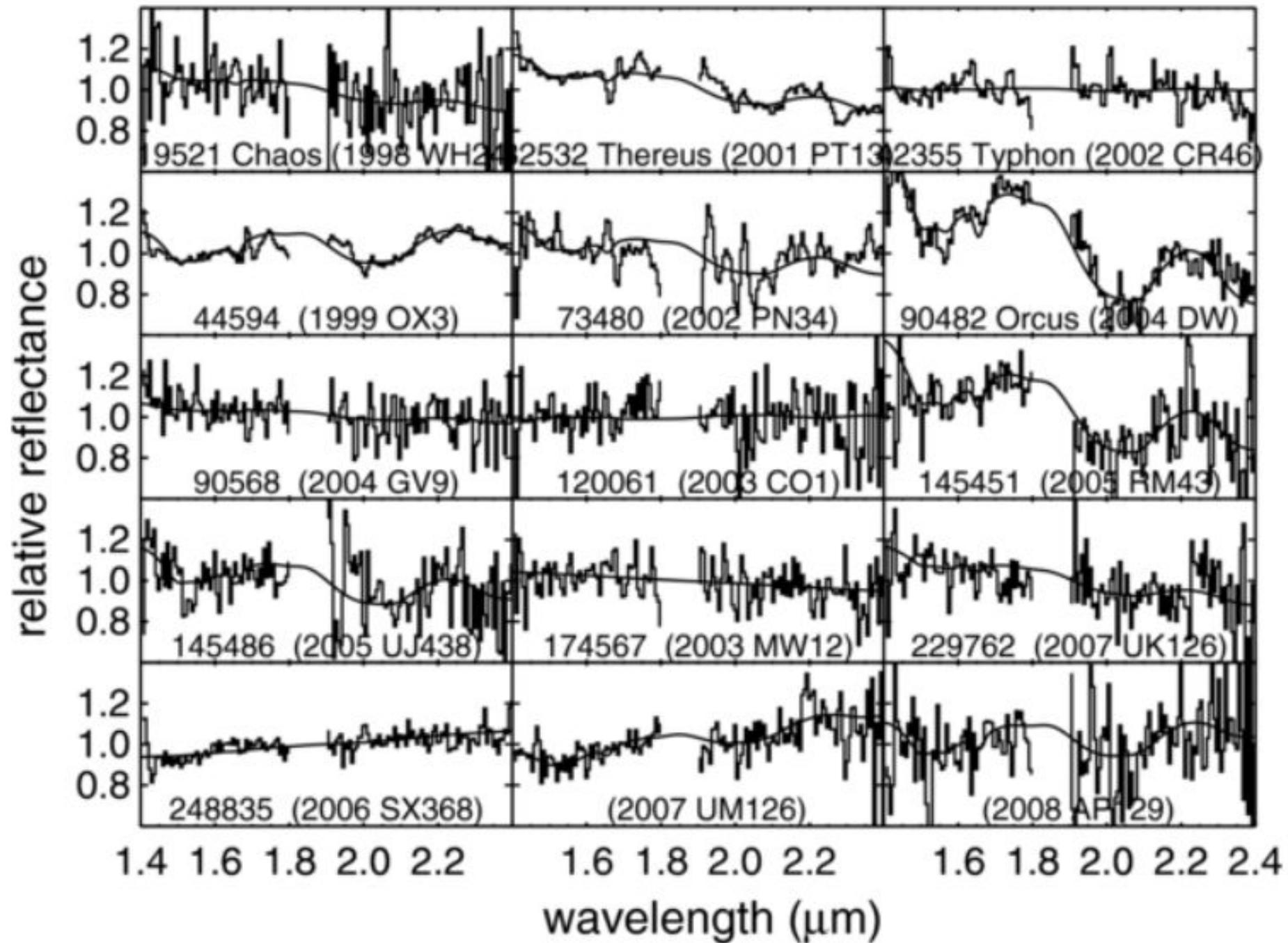


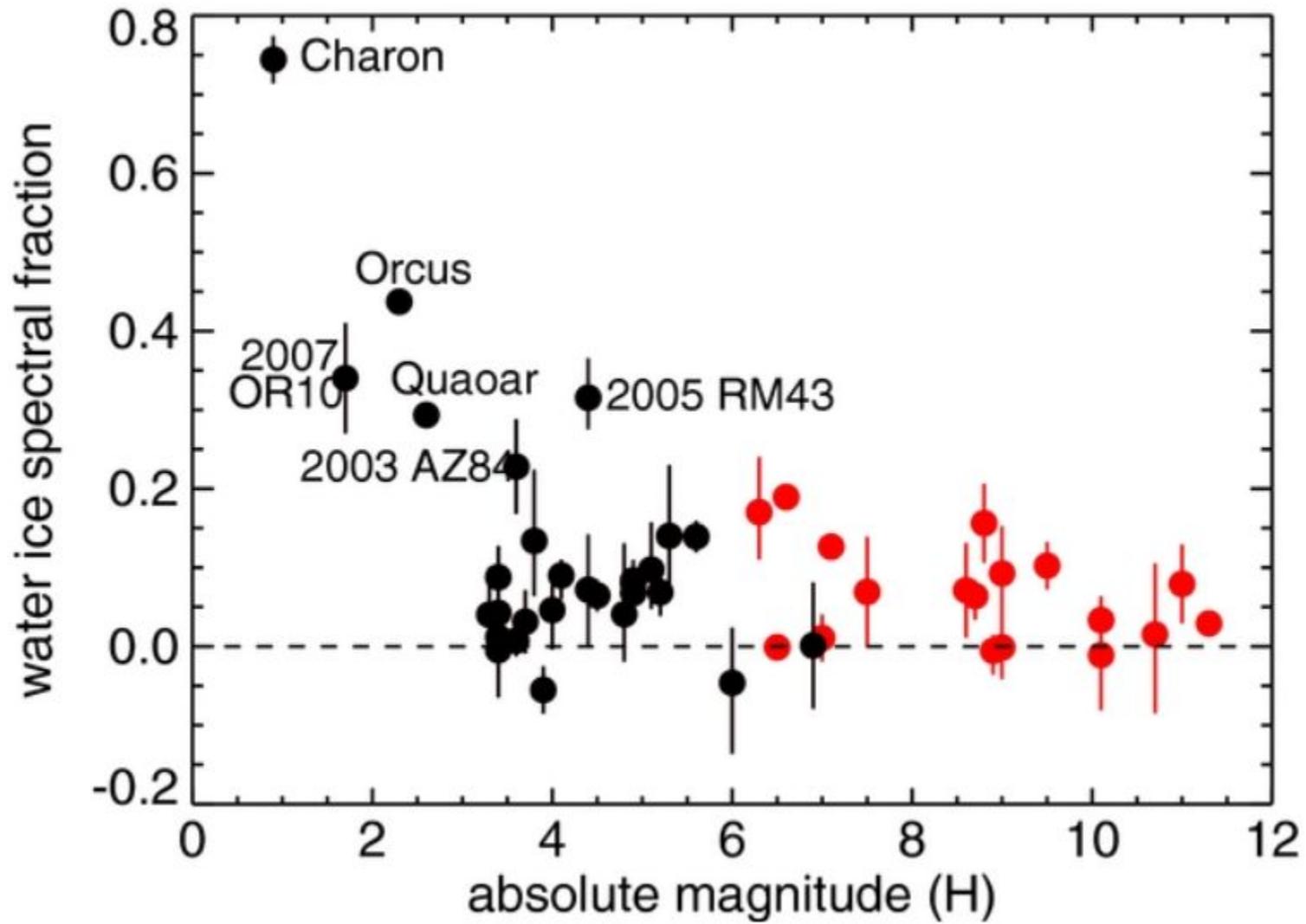
**modern Solar System**



**early Solar System**

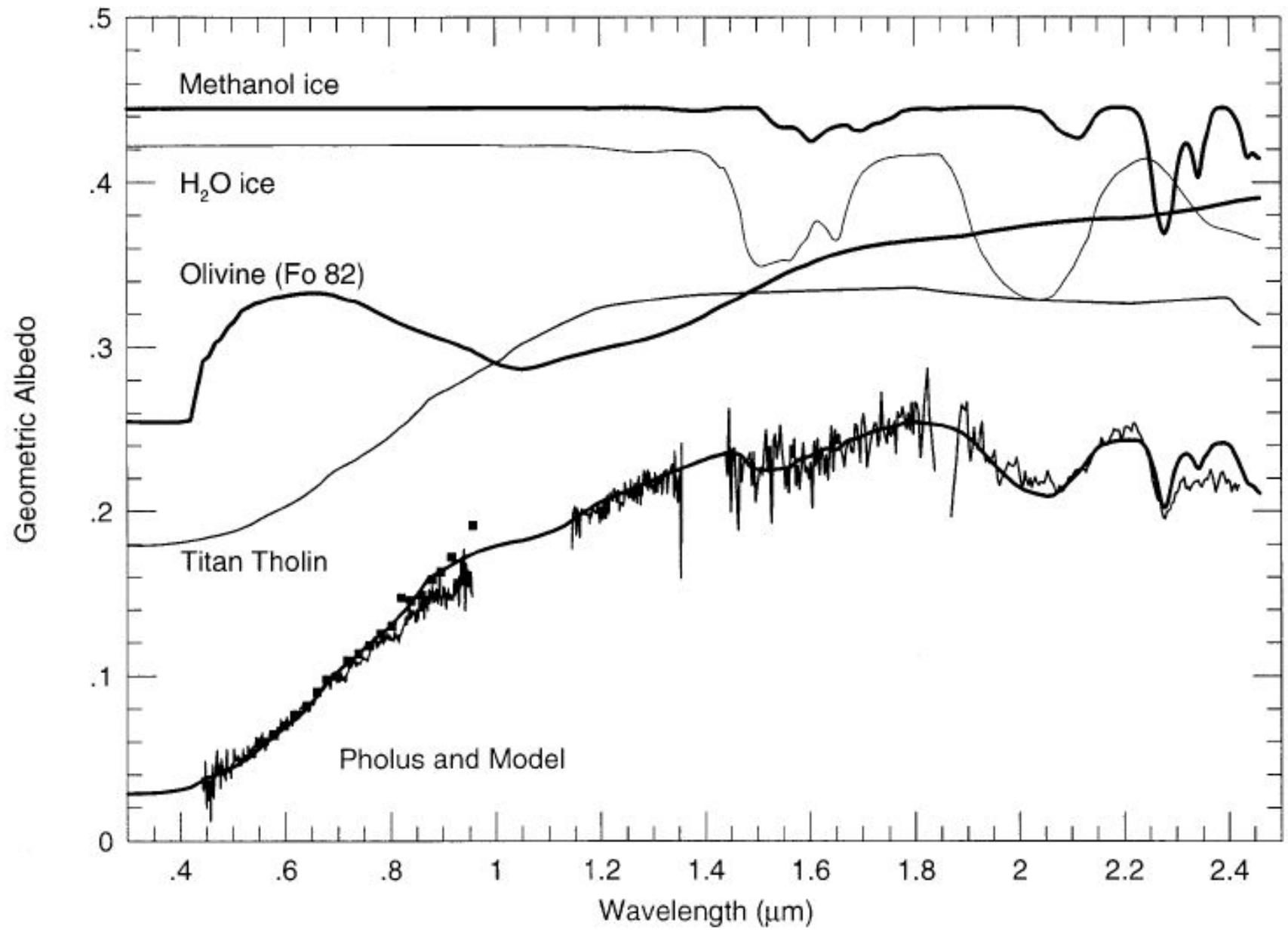
initial planetesimal disk, multiple ice lines

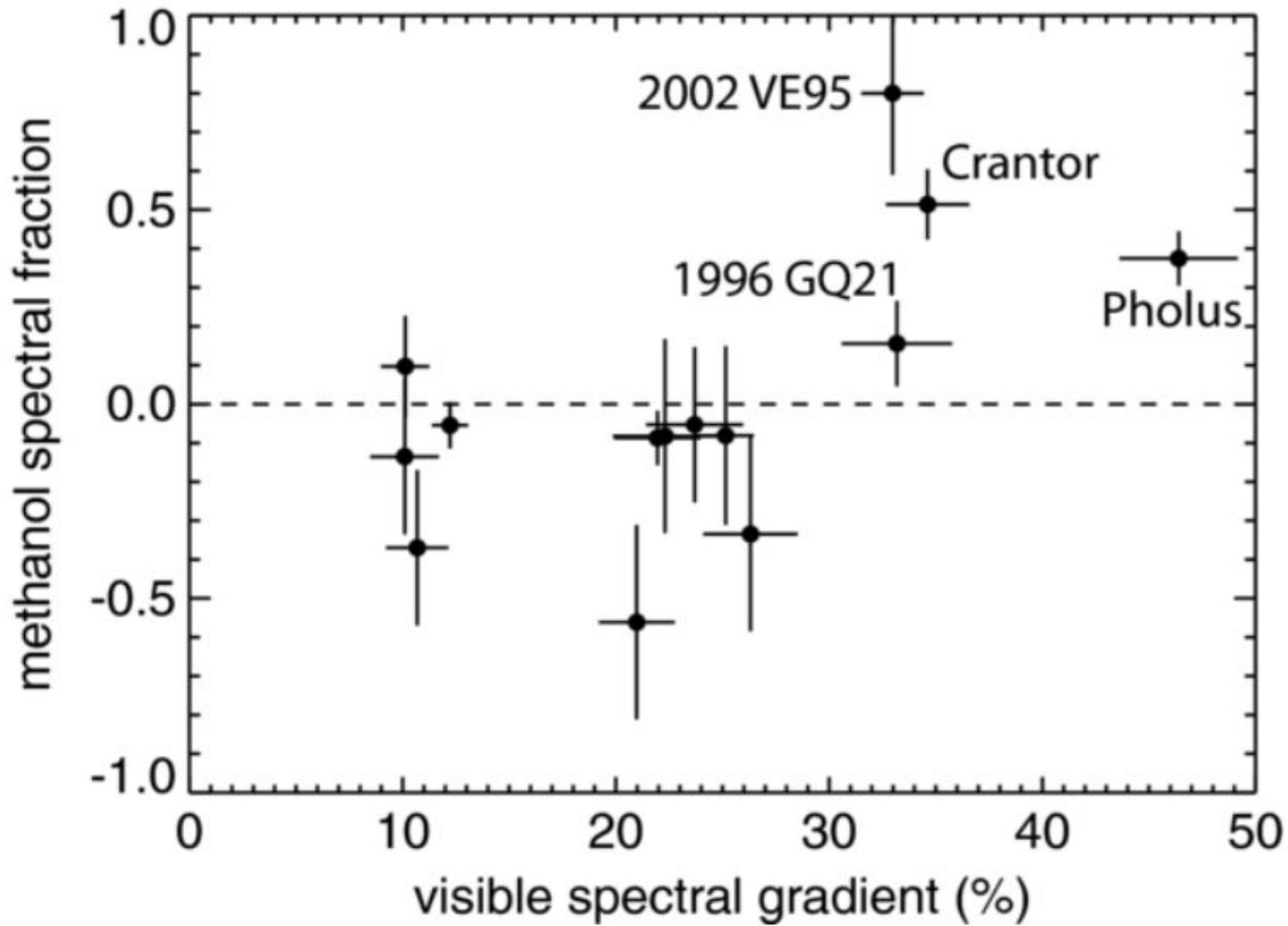




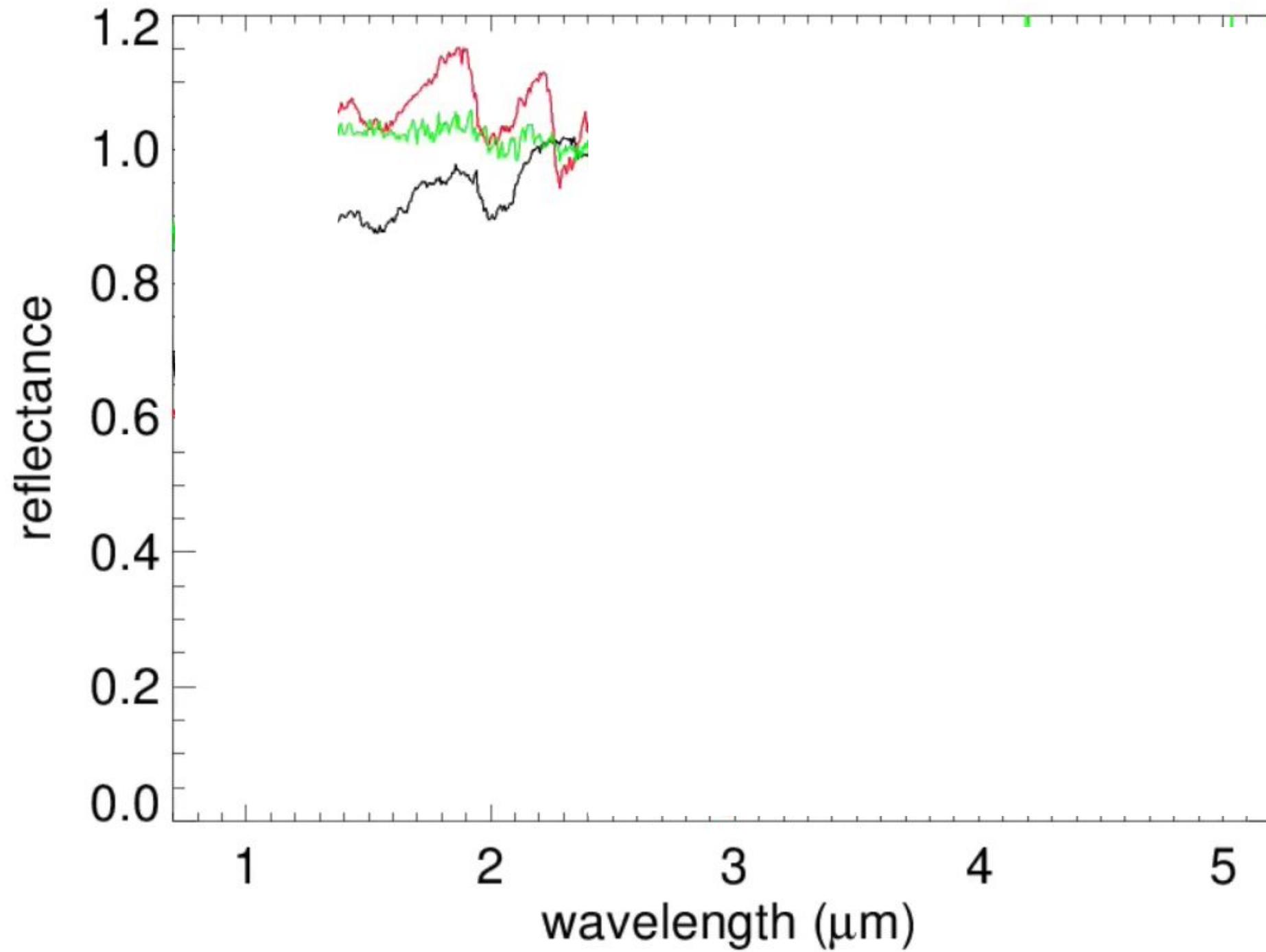
big

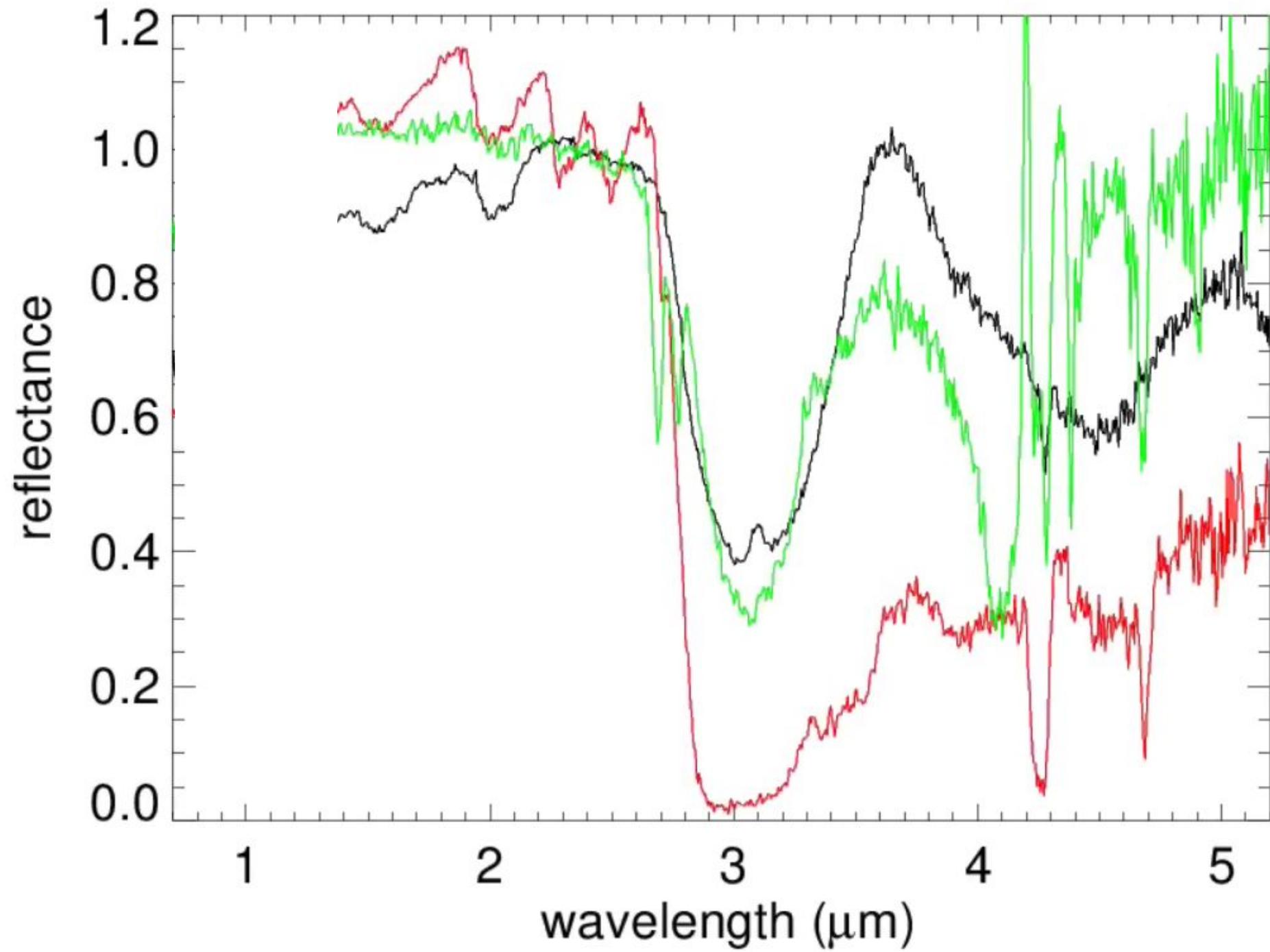
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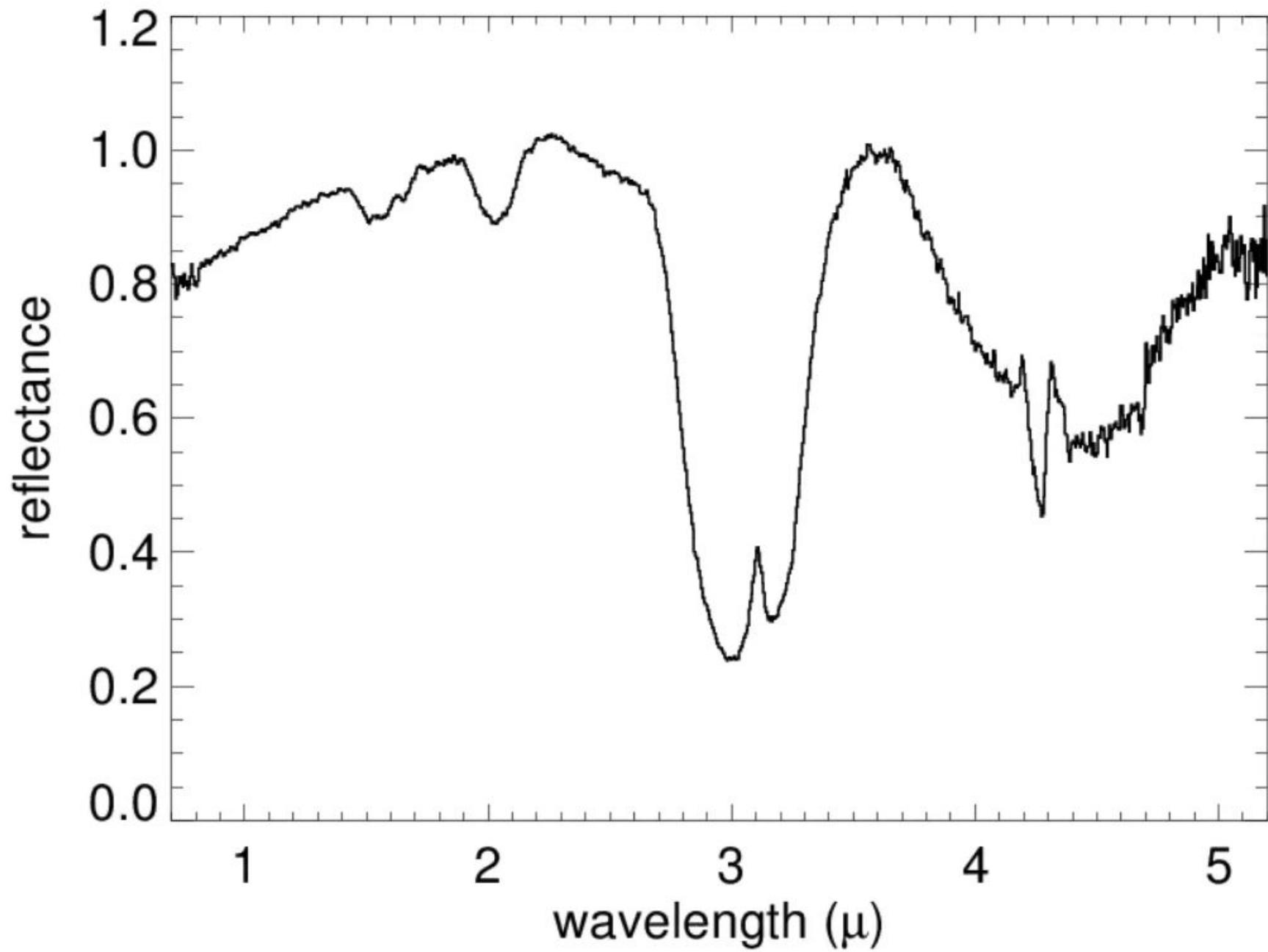


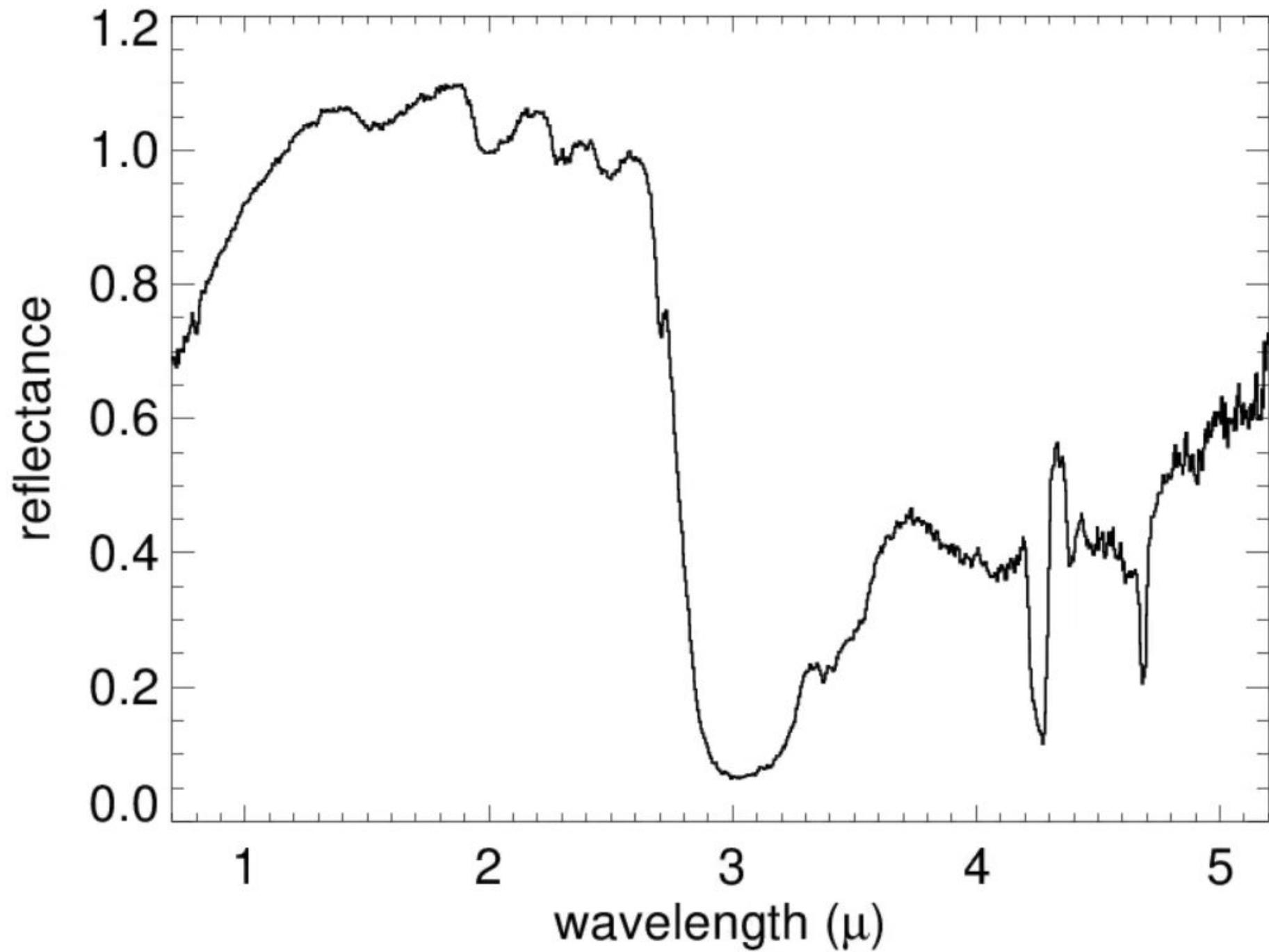


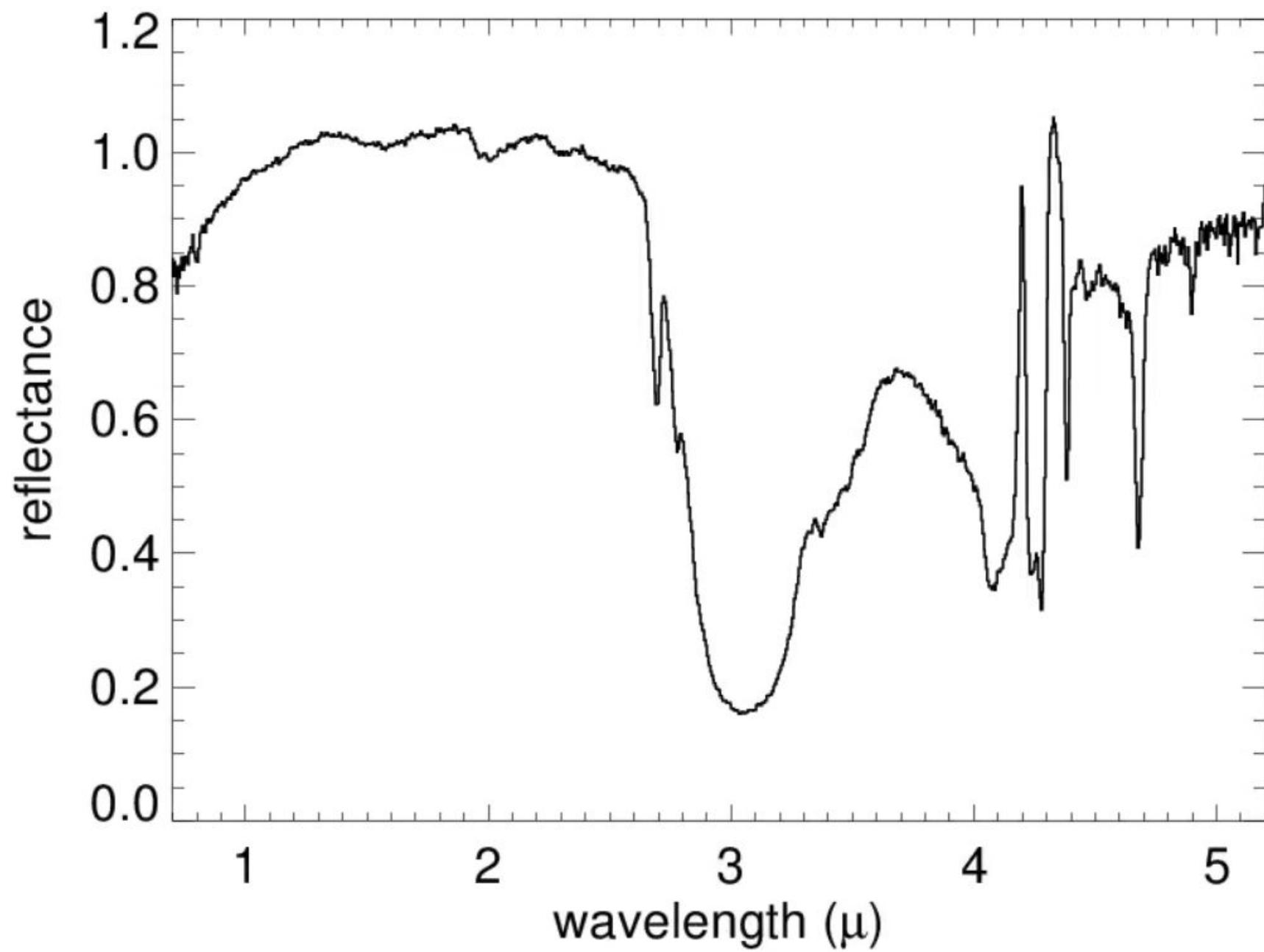


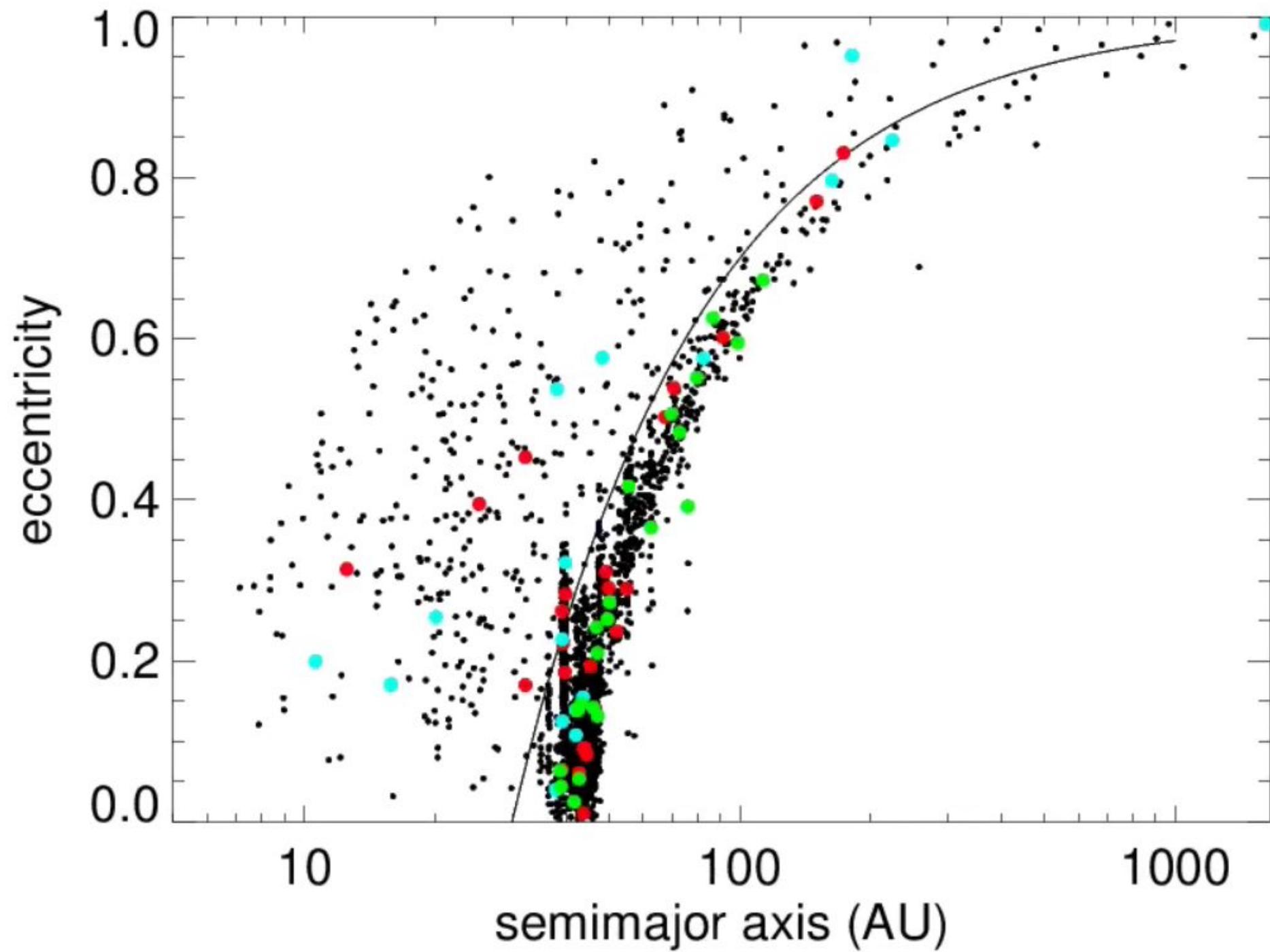




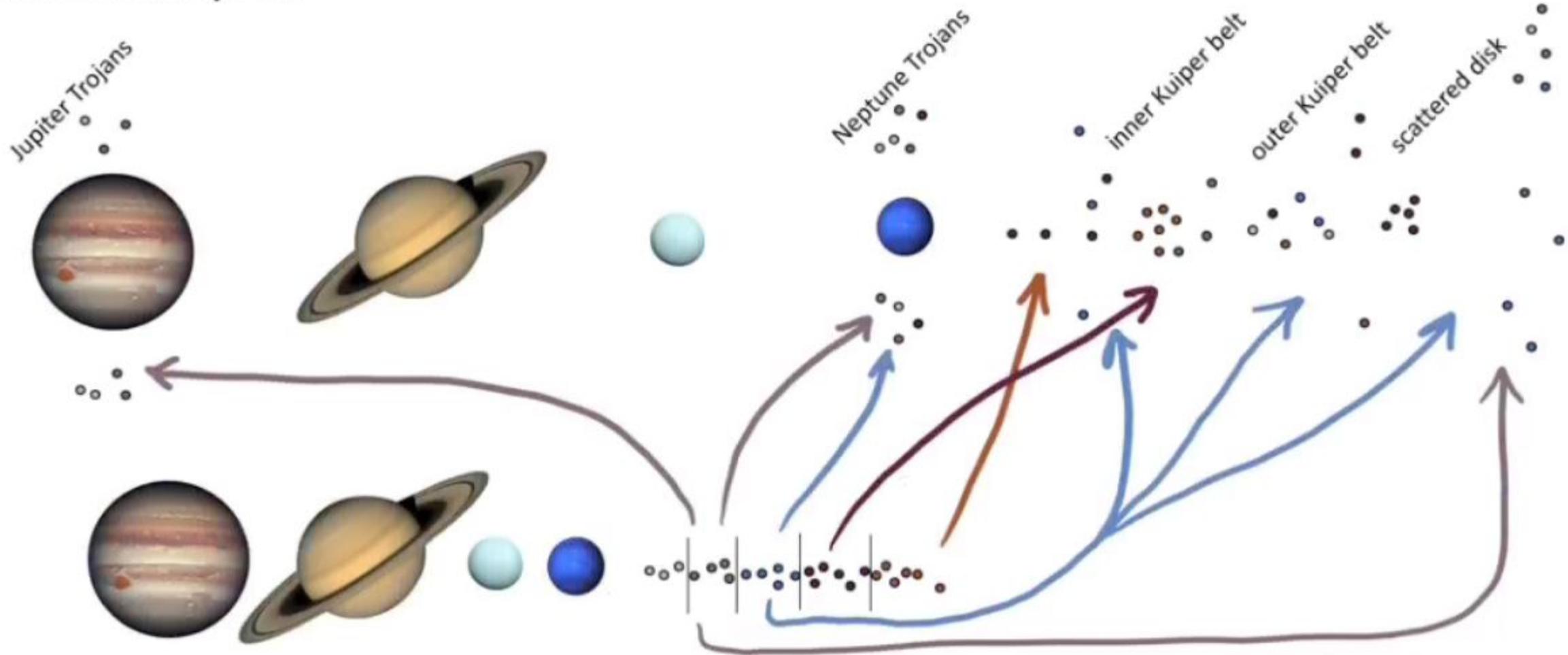






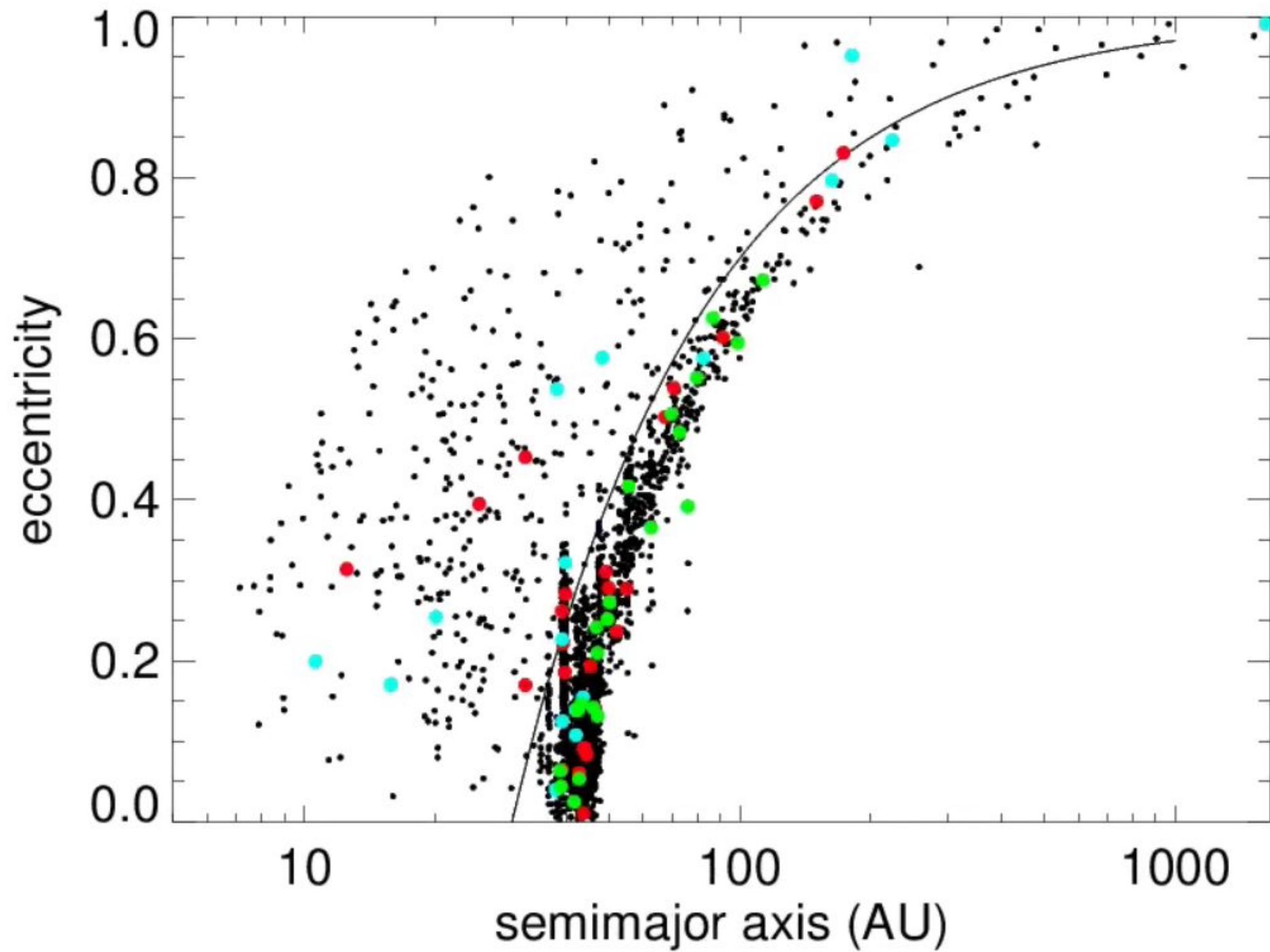


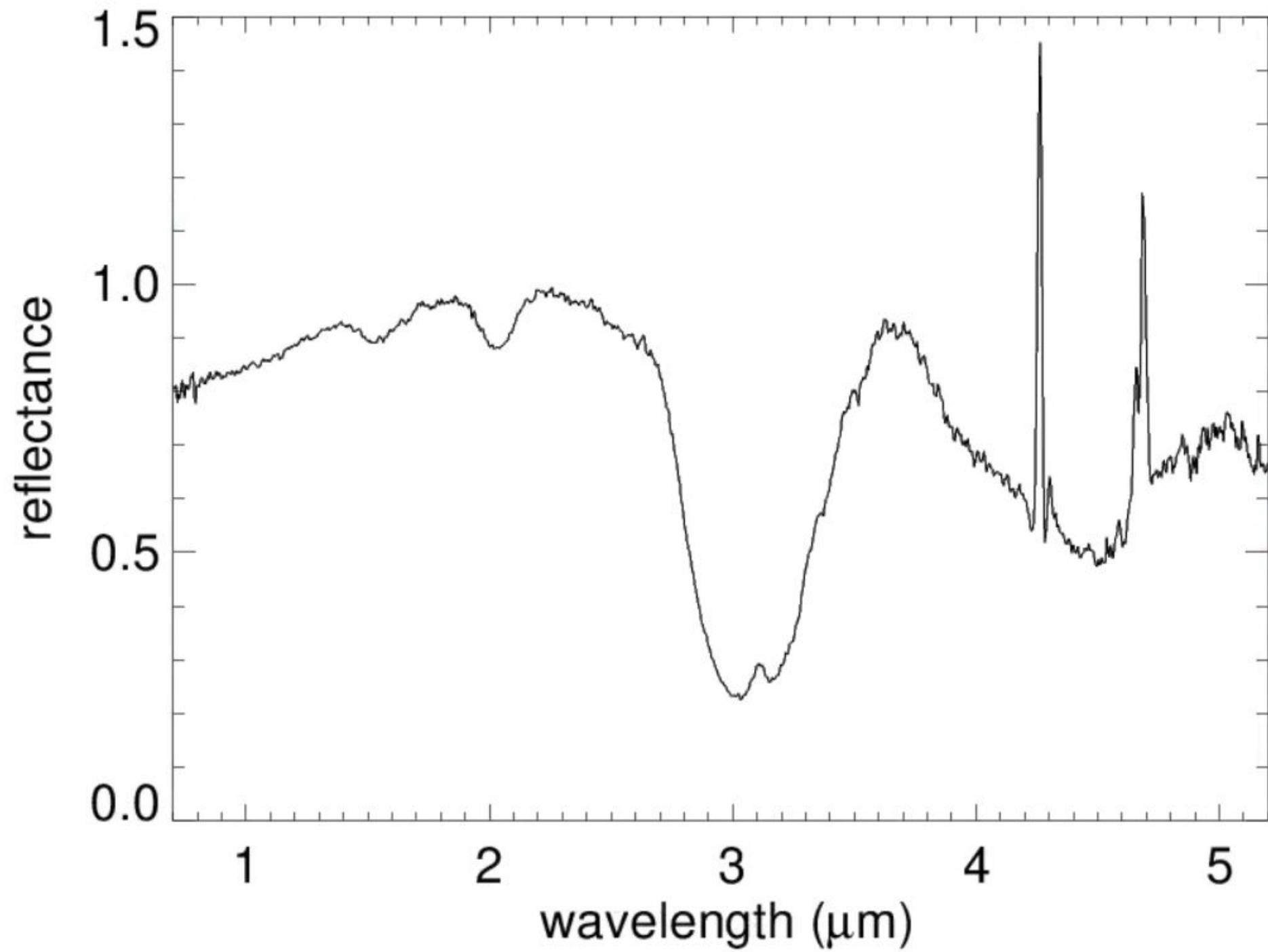
**modern Solar System**

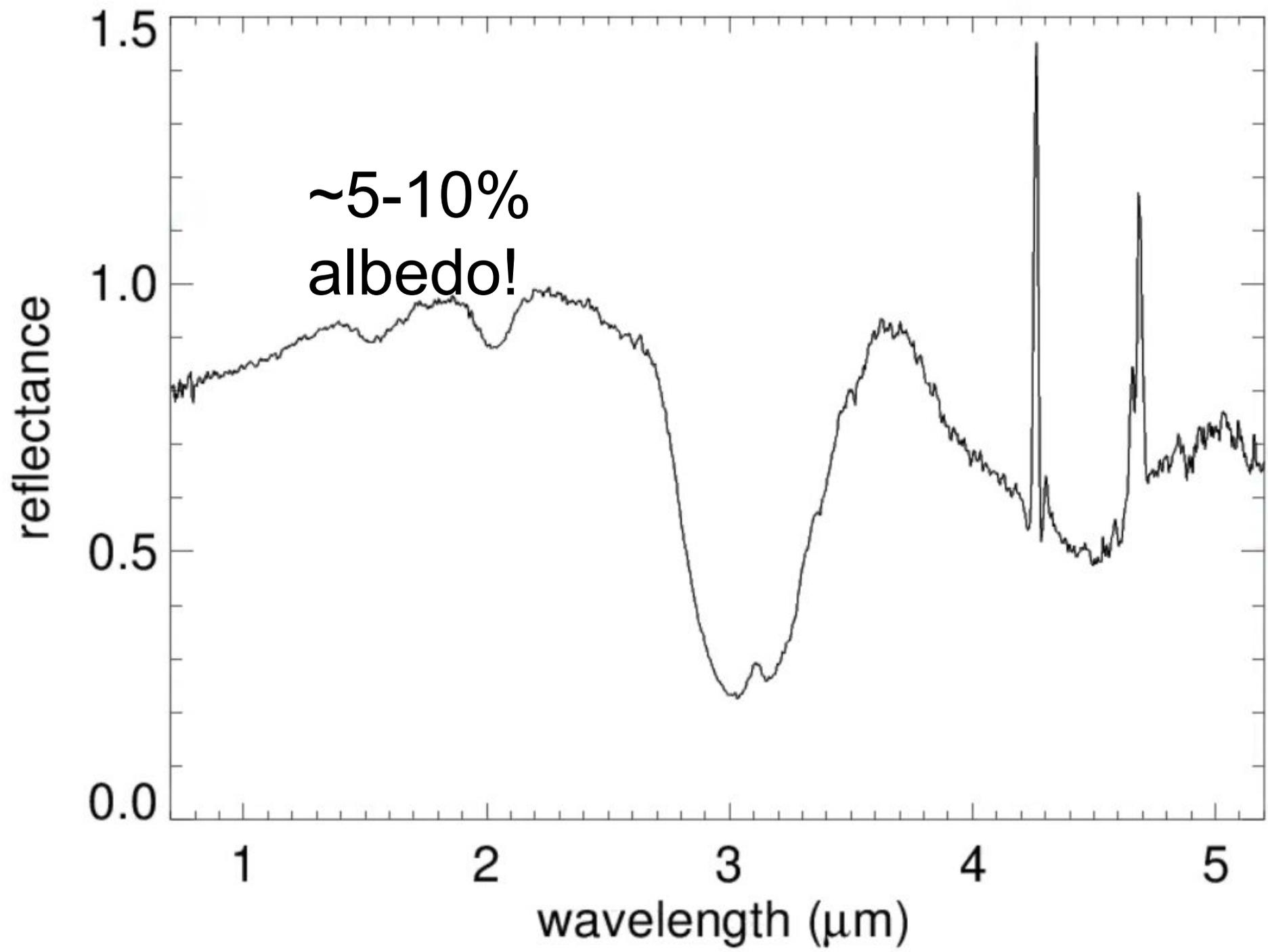


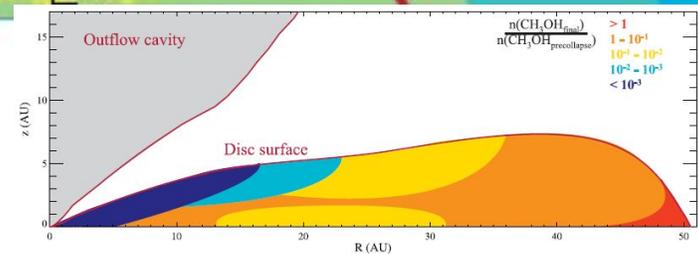
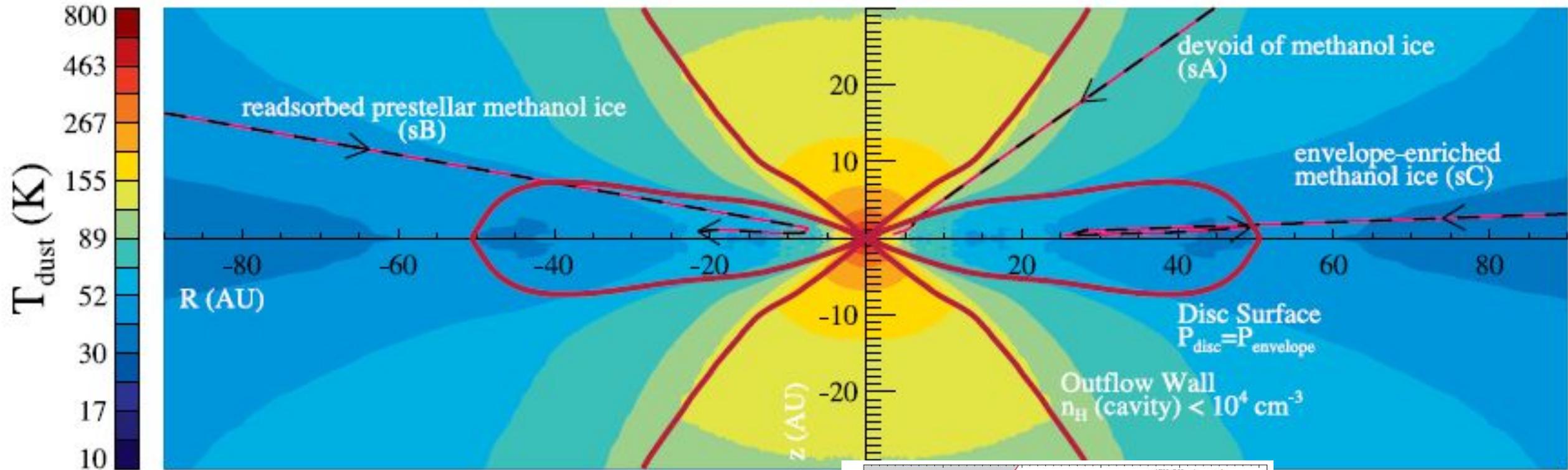
**early Solar System**

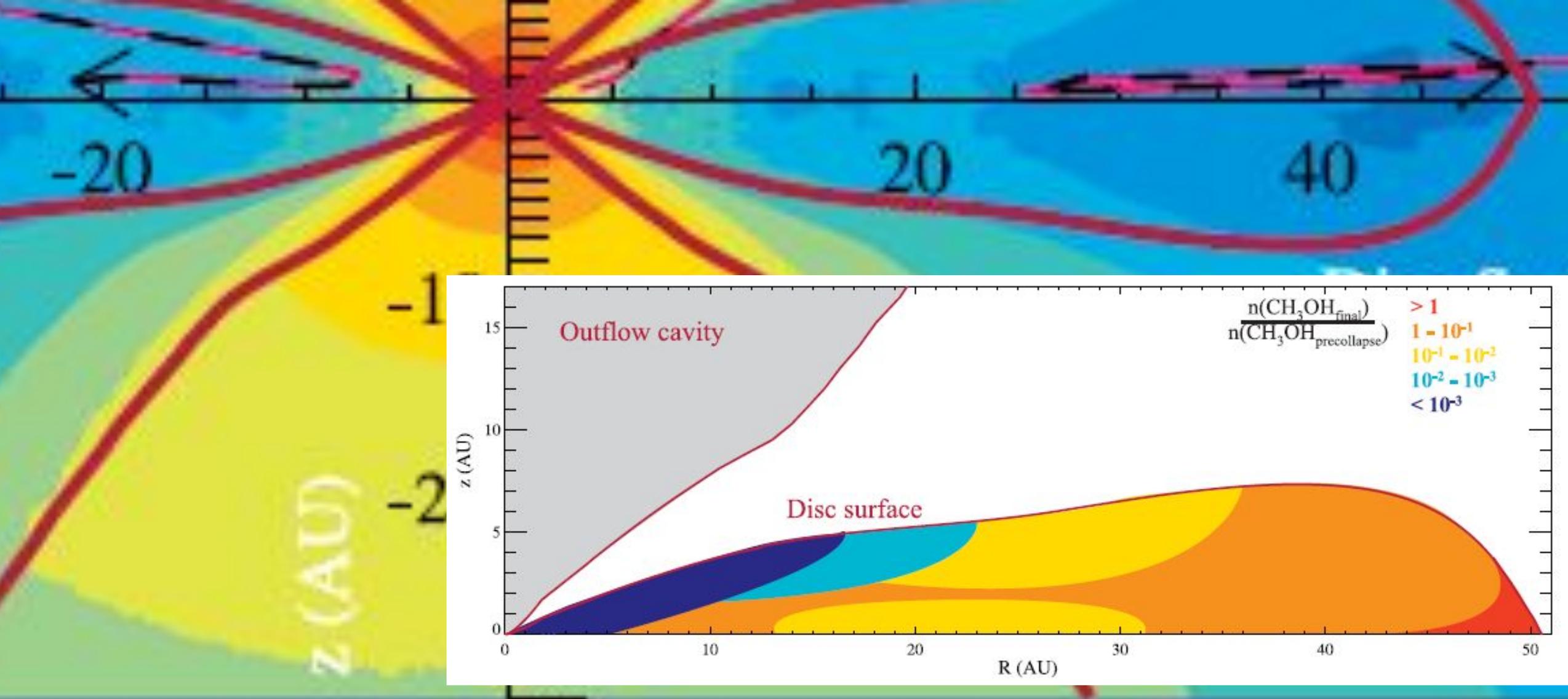
initial planetesimal disk, multiple ice lines

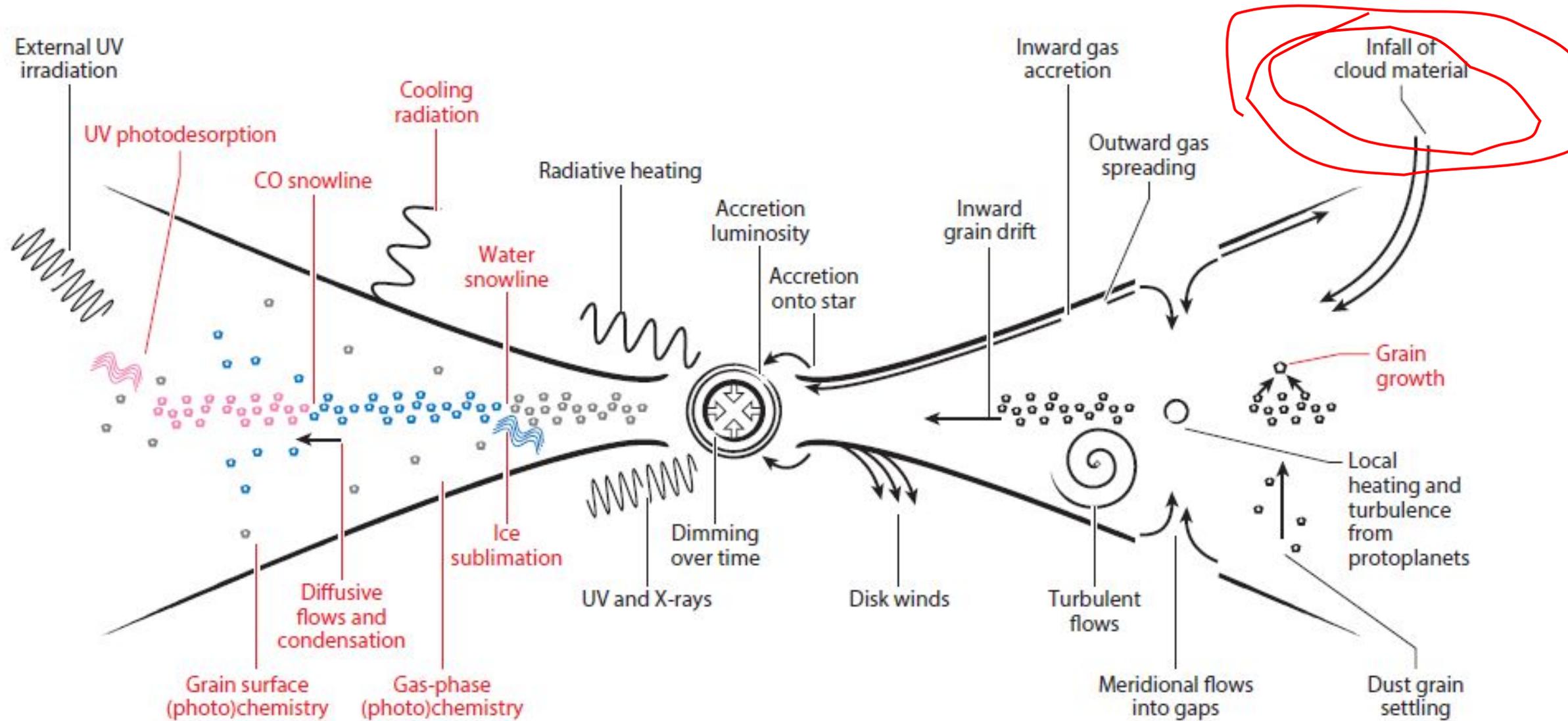






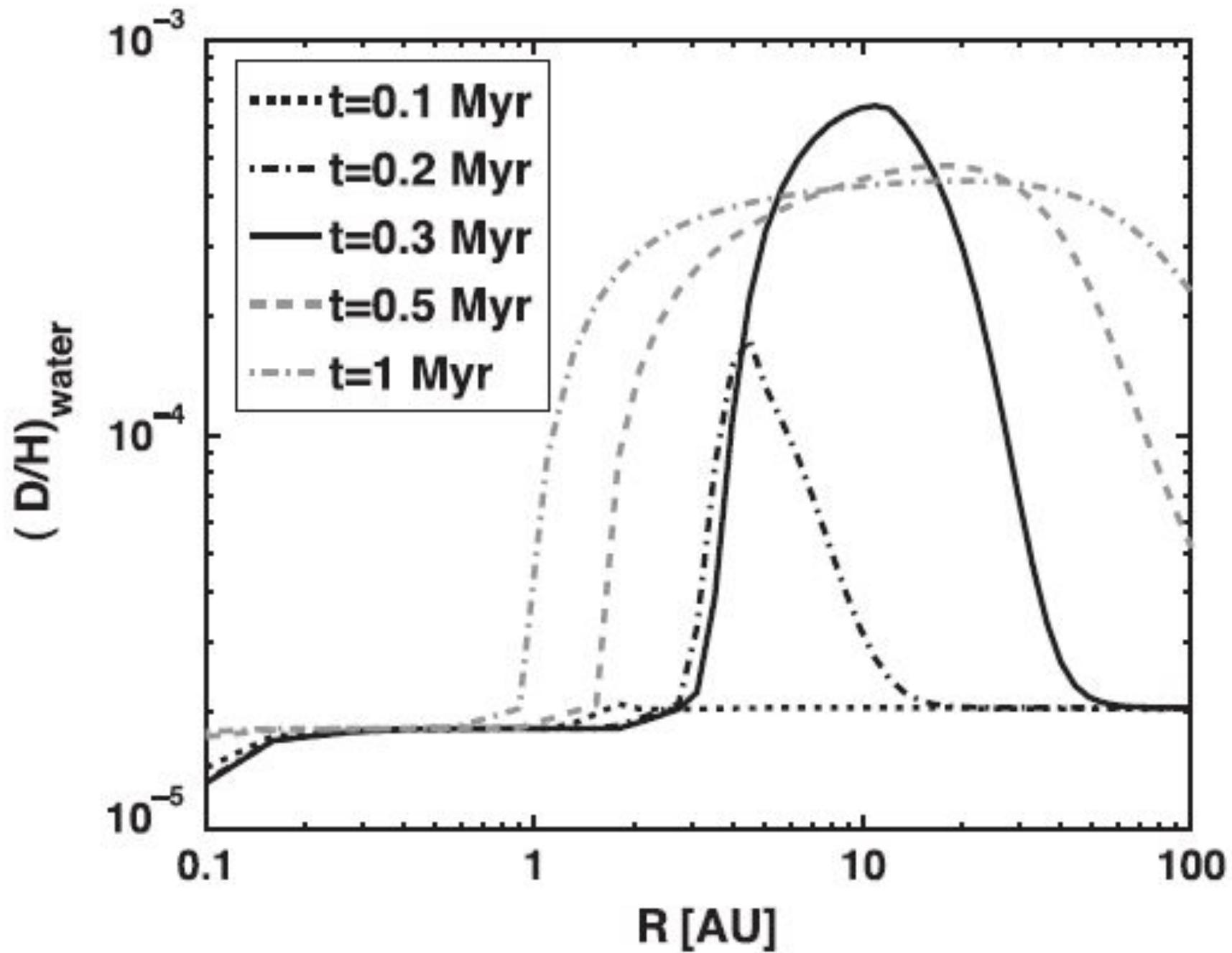


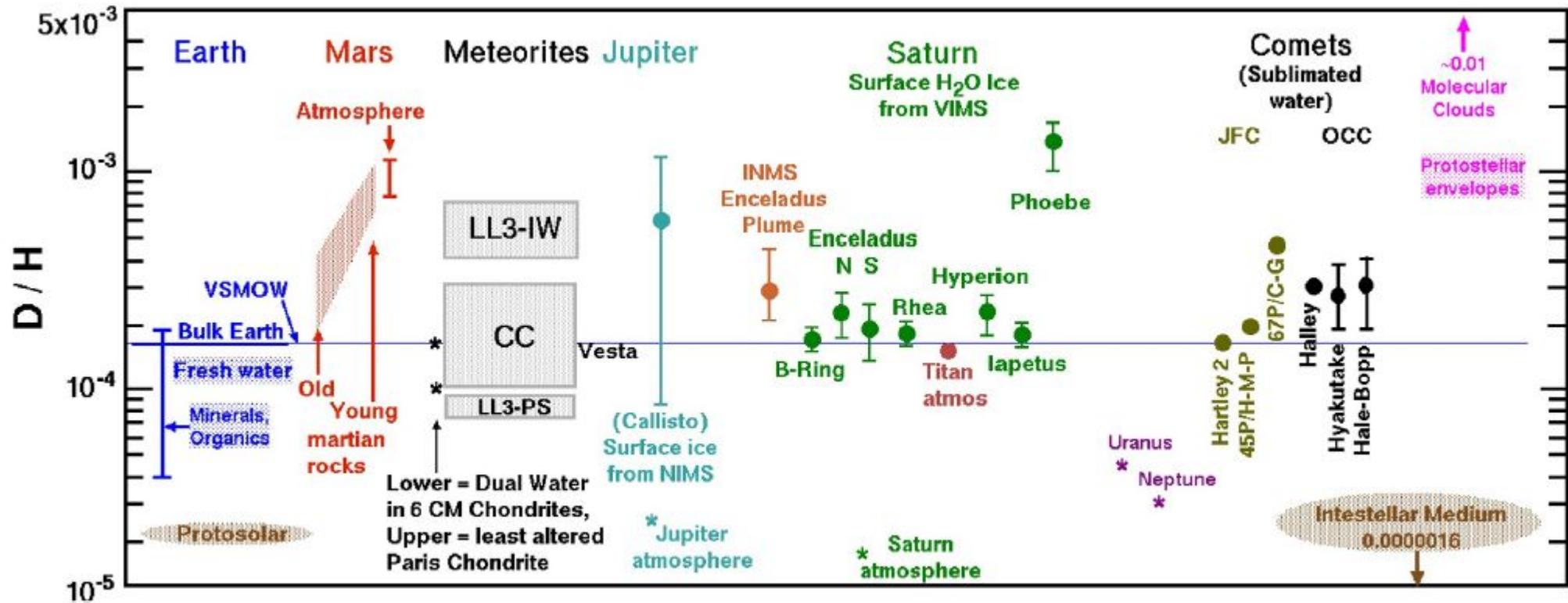


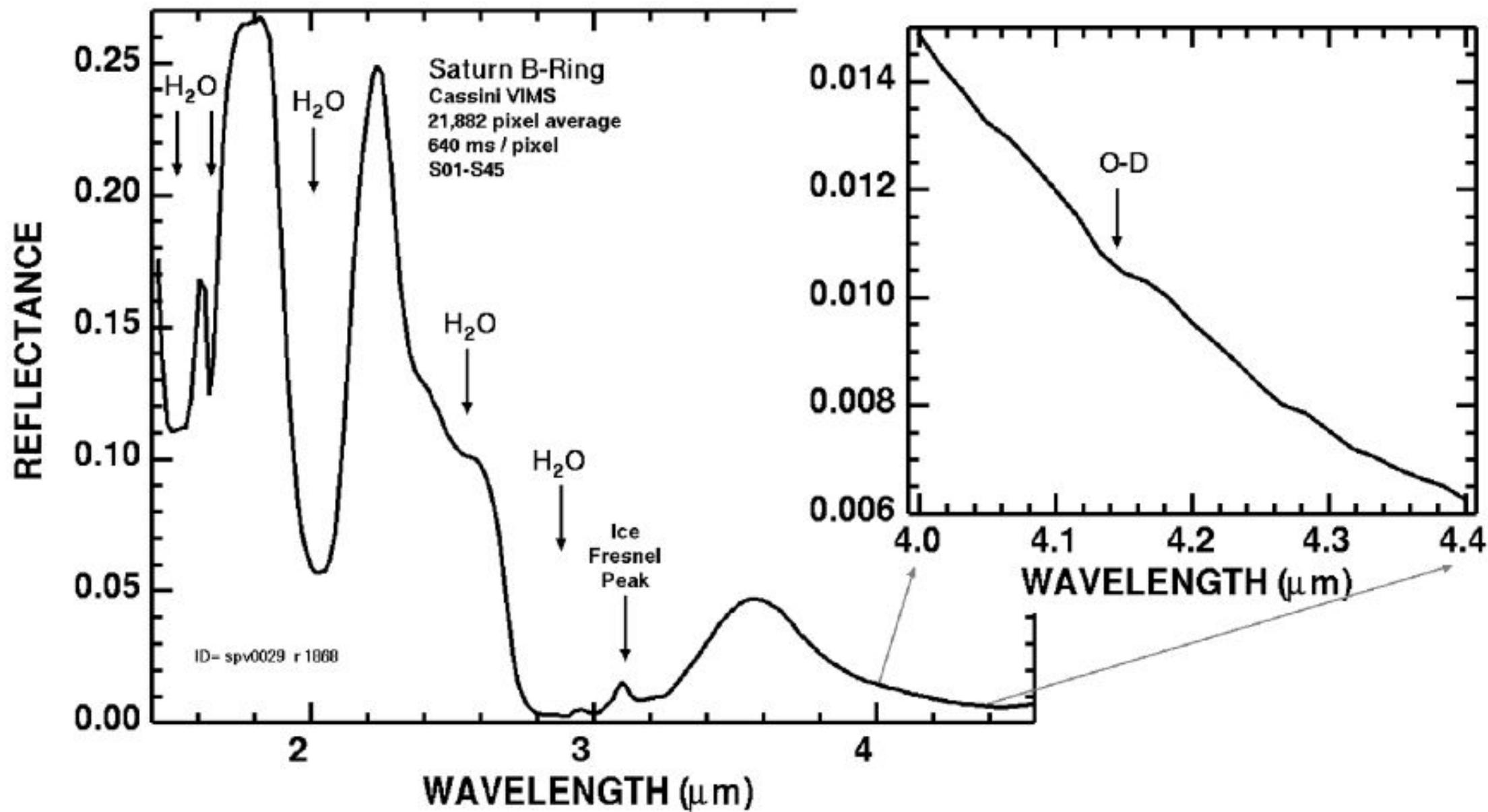


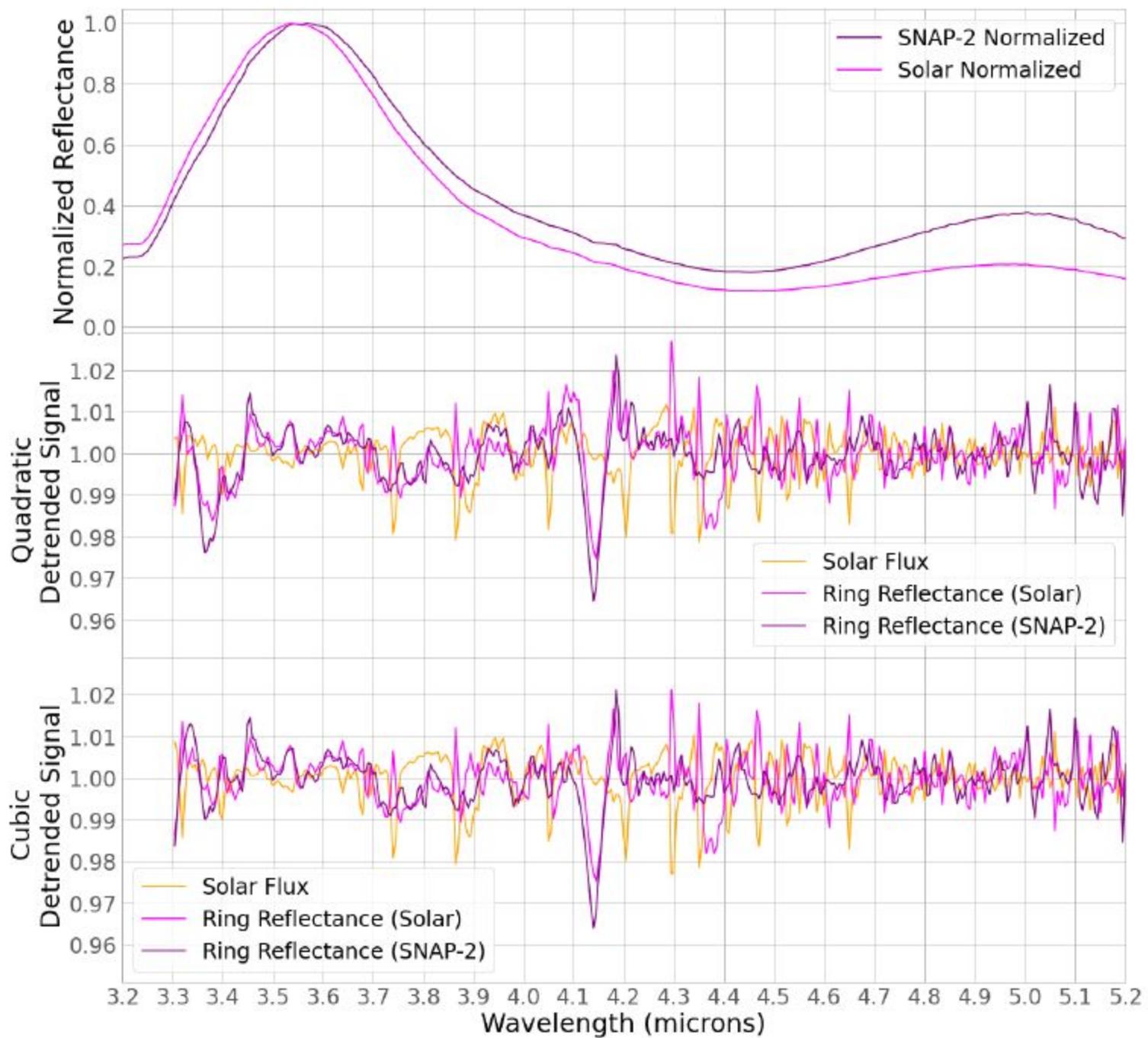
Disk and stellar  
dynamic processes  
Chemical processes

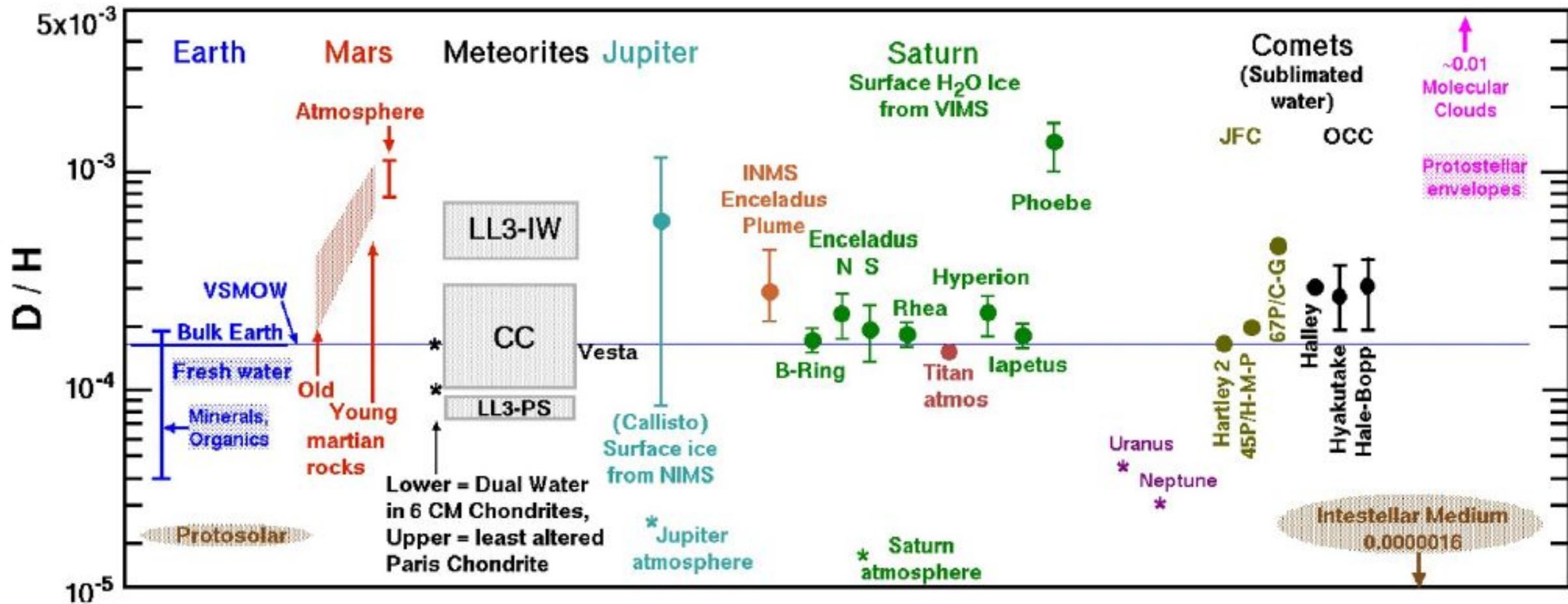
- ◻ Bare silicate grains
- ◻ Water ice-dominated grains
- ◻ Hypervolatile CO-dominated grains











Oh yeah sample return

- Bulk ice composition
- Isotopic composition
- How to get there and back