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# The surface ages of the distant alien terrain: The icy satellites in the outer Solar System

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# 1) Our journey today...

To estimate the age of the icy satellites in the outer solar system



Relative sizes in between the moons are in scale Images credit: NASA



#### Saturn's satellites system







Images credit: NASA

# 1) Our journey today...

To estimate the age of the icy satellites in the outer solar system



Images credit: NASA









# 1) Our journey today...

To estimate the age of the icy satellites in the outer solar system



#### Method 1: **Radiometric dating** of the in-situ samples



# 2) Technique of ages estimationMethod 2: Crater densities on the surface

Various impact craters on the solid bodies in the solar system





Images credit: NASA



Images credit: NASA and irasutoya

#### Craters' size-frequency distribution [ Size v.s. Density]





Images credit: Showmaker





Images credit: Showmaker

#### Craters' size-frequency distribution [ Size v.s. Density]





#### Craters' size-frequency distribution [ Size v.s. Density]











# 3) Problems in the studies of Outer Solar System



# Outer Solar System Version

#### Aim:

- 1) Construct the crater chronology of outer solar system
- 2) Determine ages of the icy regular satellites of the giant planets
- Method:Computer simulationAnalytical calculationCrater studies
- ✓ Jupiter (Ganymede and Callisto)
  ✓ Saturn (Mimas, Enceladus, Tethys, Dione, Rhea)
  ✓ Uranus (Miranda, Ariel, Umbriel, Titania, and Oberon)



#### Assumption:

- 1) Satellites formed with giant planets
- 2) Satellites has no surface activities since their formation

#### Calculate:

#### **Expected crater density**

crater density that the satellites would have been if there is no surface activities since their crust solidified.





#### Evolution of the solar system according to Nice Model

- i) Giant planets migration at 4.5 Ga
- ii) Planetesimals scattered



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#### 5) Results: Age estimations



# 6) Highlight

- 1) First update in crater chronology since two decades ago.
- 2) Comprehensive studies of the Outer Solar System bring insight to answer question related to the Inner Solar System.

The Galilean satellites (Moons of Jupiter)

3) Help the future space mission:
 NASA's Clipper mission → Europa
 ESA's JUICE mission → Ganymede



### 

#### 7) Conclusions

- 1) The impact in the outer solar system happened much more rapid.
- 2) Surface ages :
  - Most satellites are ancient, ~4.3 Ga Small and close-in satellites ~ 3.8 to 4.1 Ga.

Looking forward to the discussions

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