

# ASTRONOMY 161

## Introduction to Solar System Astronomy



COMETS

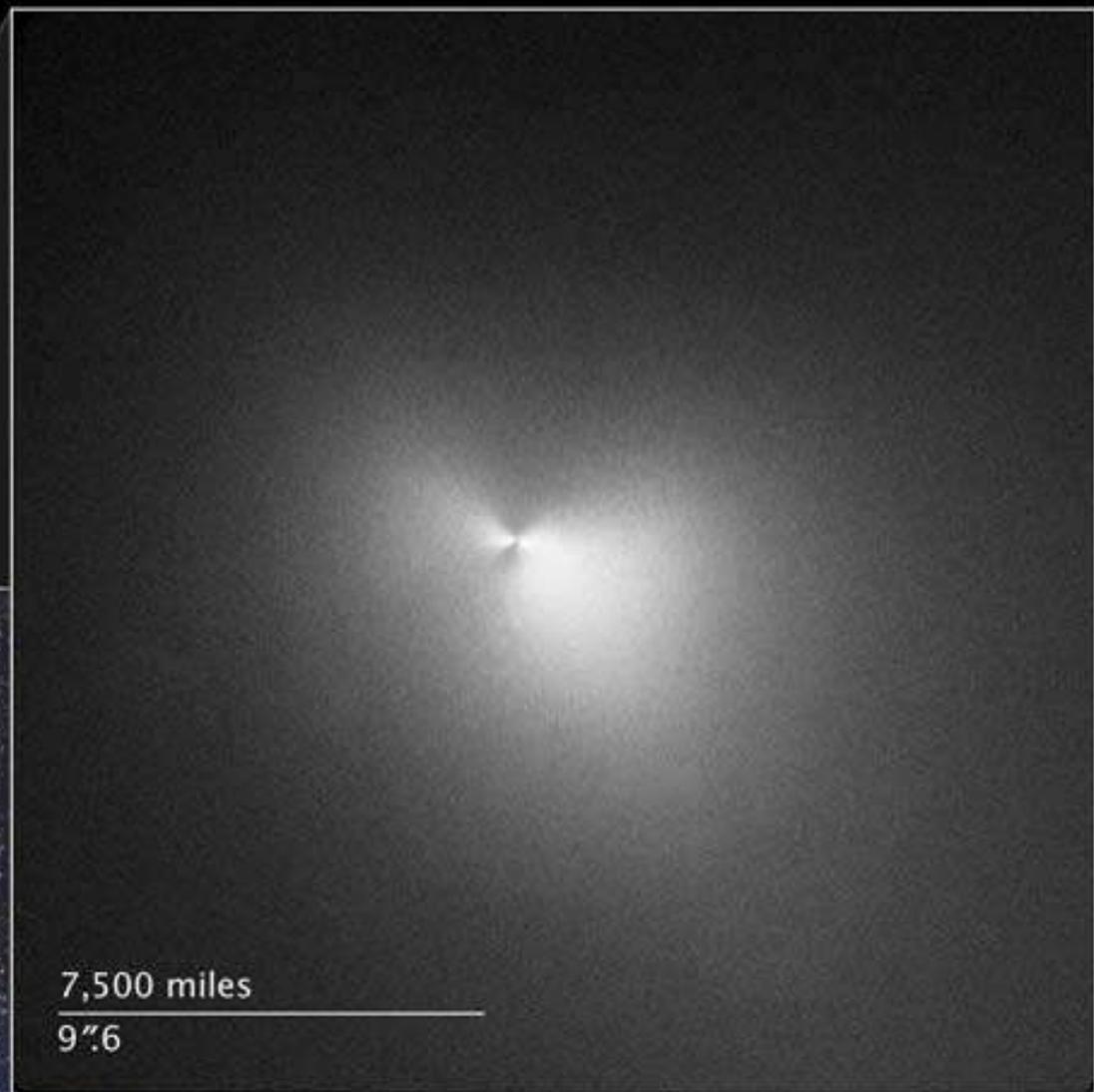
A bright comet streaking across a starry night sky. The comet's nucleus is a bright, glowing white-yellow sphere on the right side, with a long, diffuse, blue-tinted tail extending towards the left. The background is a dark blue-black sky filled with numerous small, white stars of varying brightness.

# Comets

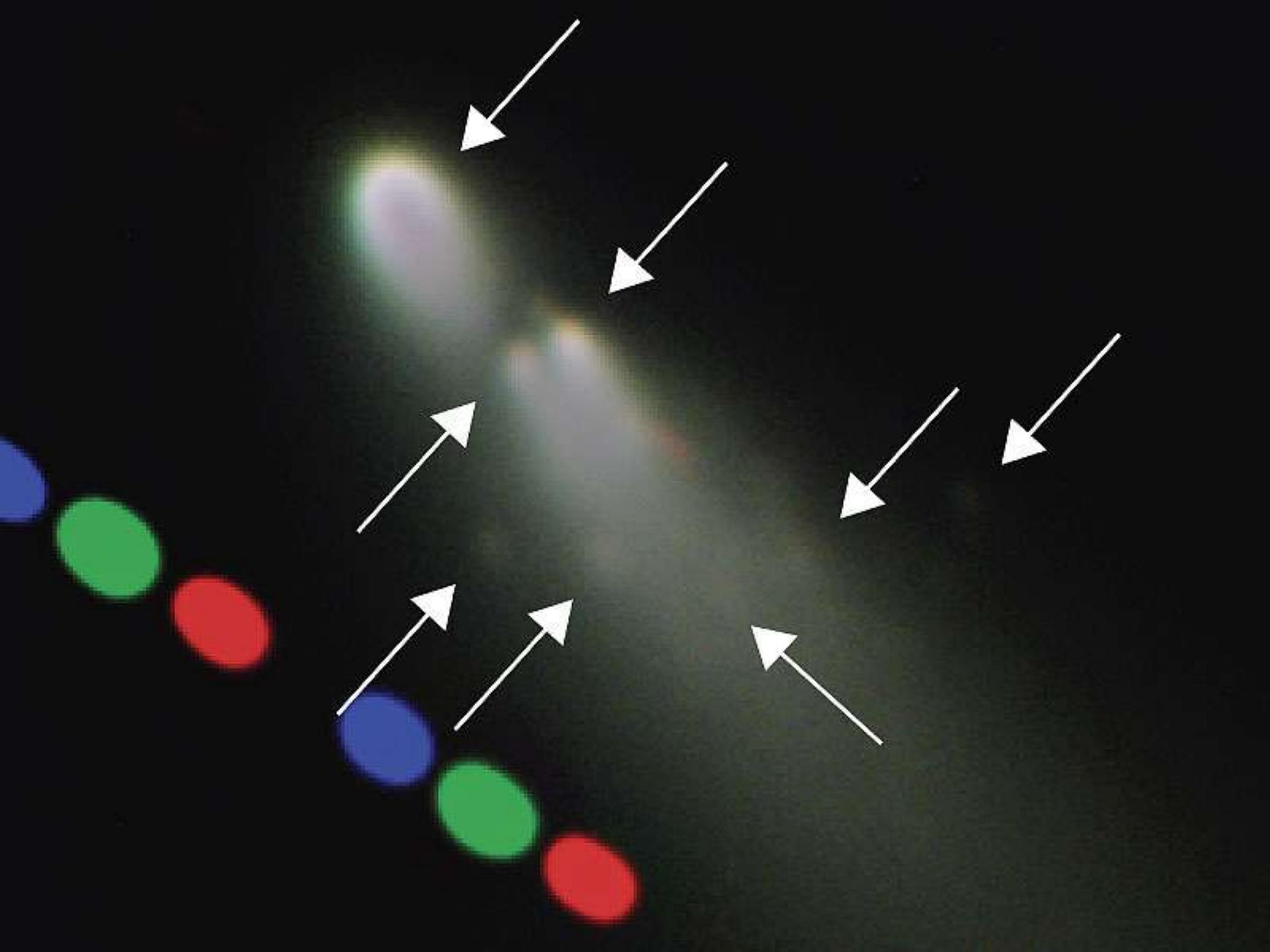
*Friday, March 7*

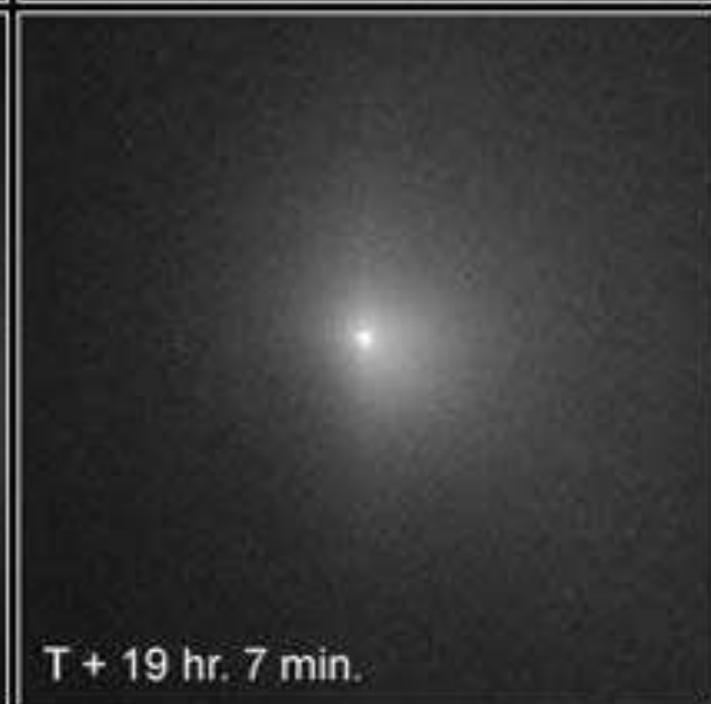


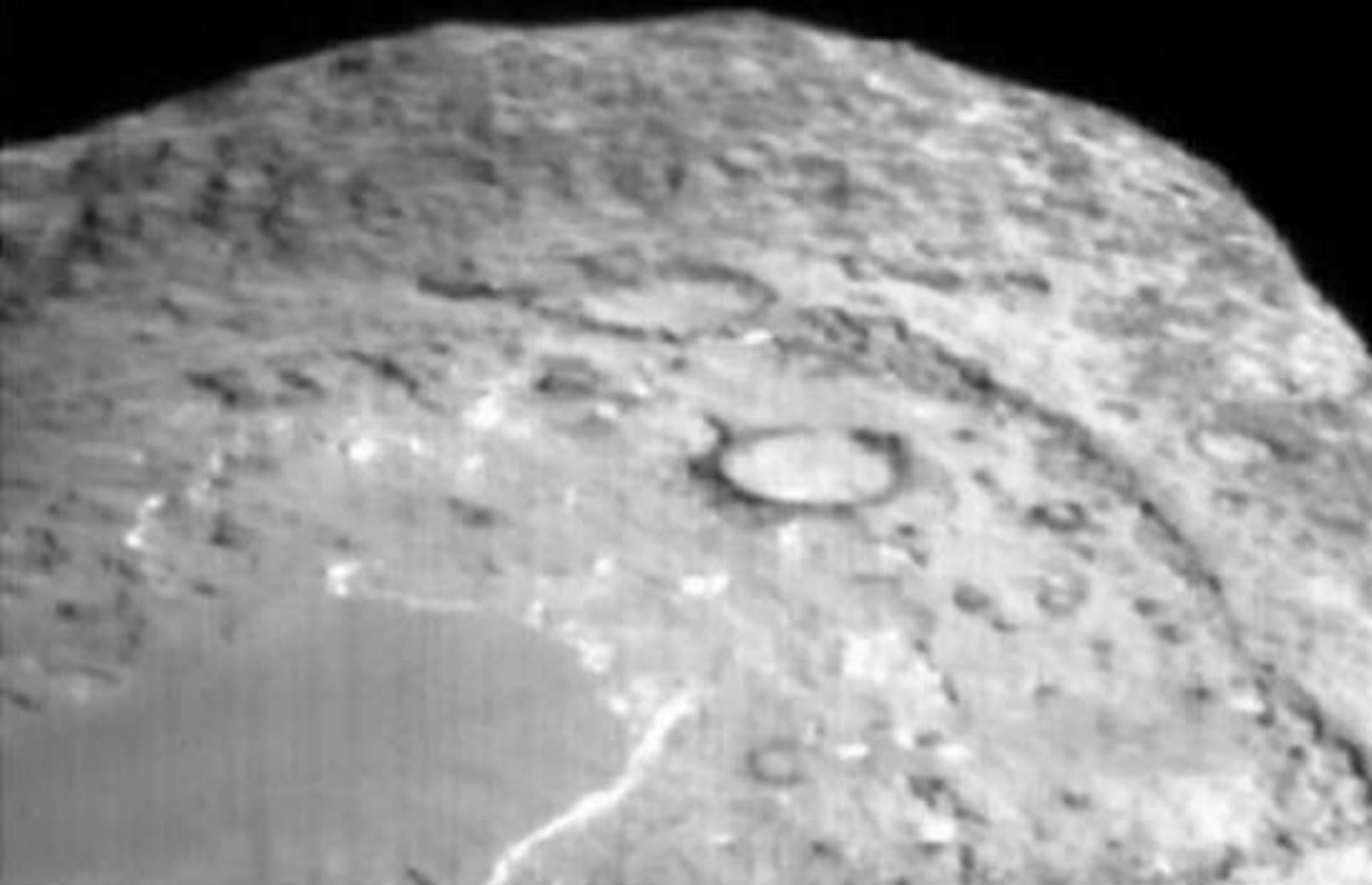
November 1, 2007  
A. Dyer, Alberta, Canada



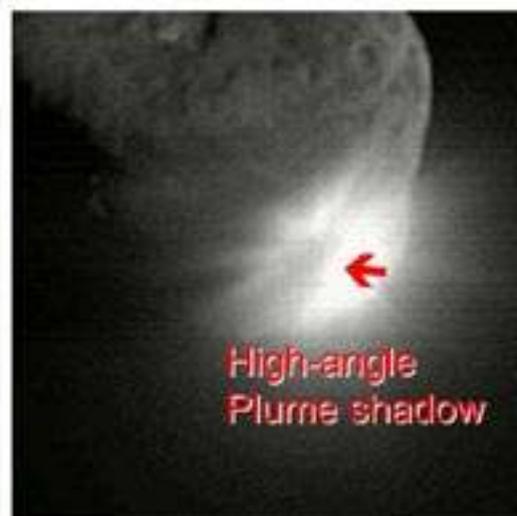
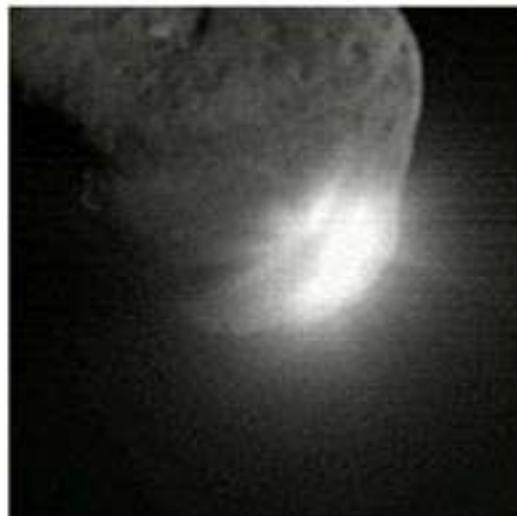
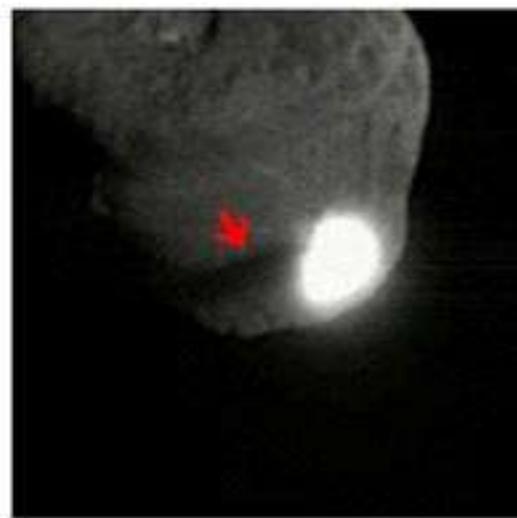
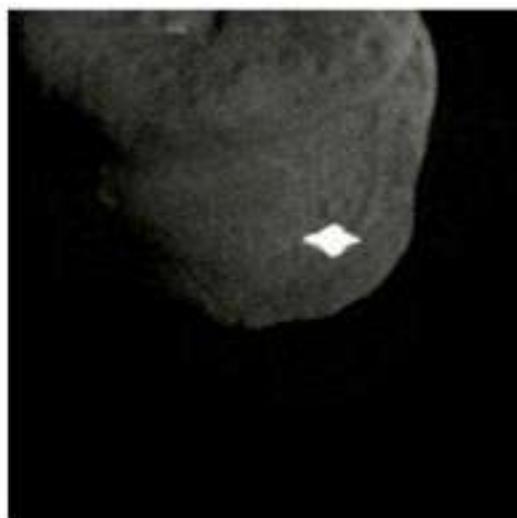
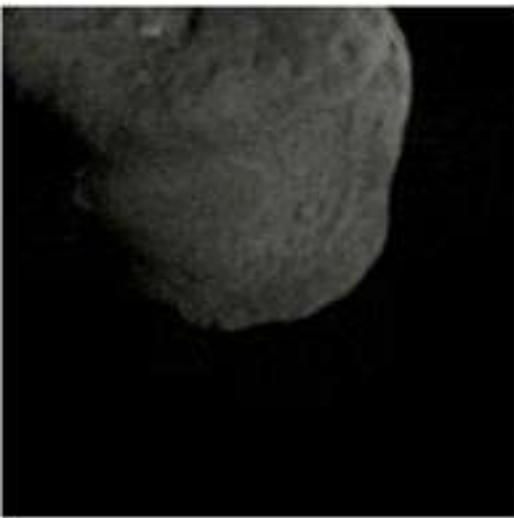
November 4, 2007  
HST WFPC2











# Comets: Key Concepts

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- (1) Comets are “dirty snowballs”: ice mixed with dust & carbon compounds.
- (2) When a comet is close to the Sun, it grows an ion tail and a dust tail.
- (3) Most comets are in the Kuiper belt or the Oort cloud, far from the Sun.
- (4) A comet or asteroid impact may have caused the extinction of dinosaurs.

“Naked-eye”  
comets are  
spectacular:  
for much of  
history they  
were  
unpredictable.

*Adoration of  
the Magi,  
Giotto,  
AD 1304*



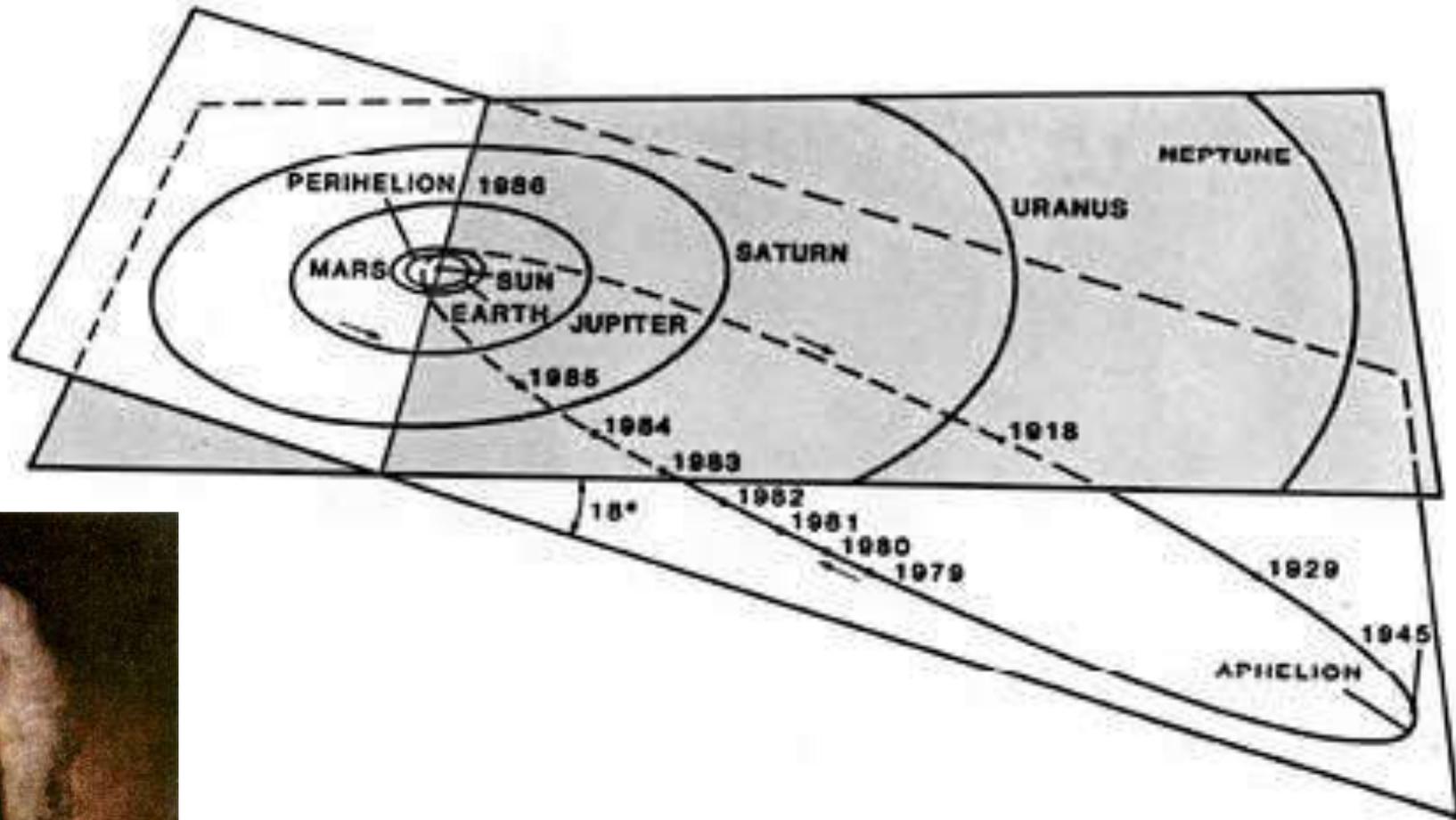
18<sup>th</sup> Century: Edmund Halley found that a comet in AD 1607 had the same orbit as a comet in AD 1682 --  
**It is the same comet!**



Now called **comet Halley**; its most recent return was in 1986.



Comet Halley has an orbit which is highly **eccentric**, highly **inclined**, and **retrograde**.



Orbital period of 76 years.

(1) Comets are “dirty snowballs”: ice mixed with dust and carbon compounds.

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Strip away their tails, and comets are just **snowballs** several km across.

A comet contains:

**frozen water,**

**frozen carbon dioxide,**

**ammonia,**

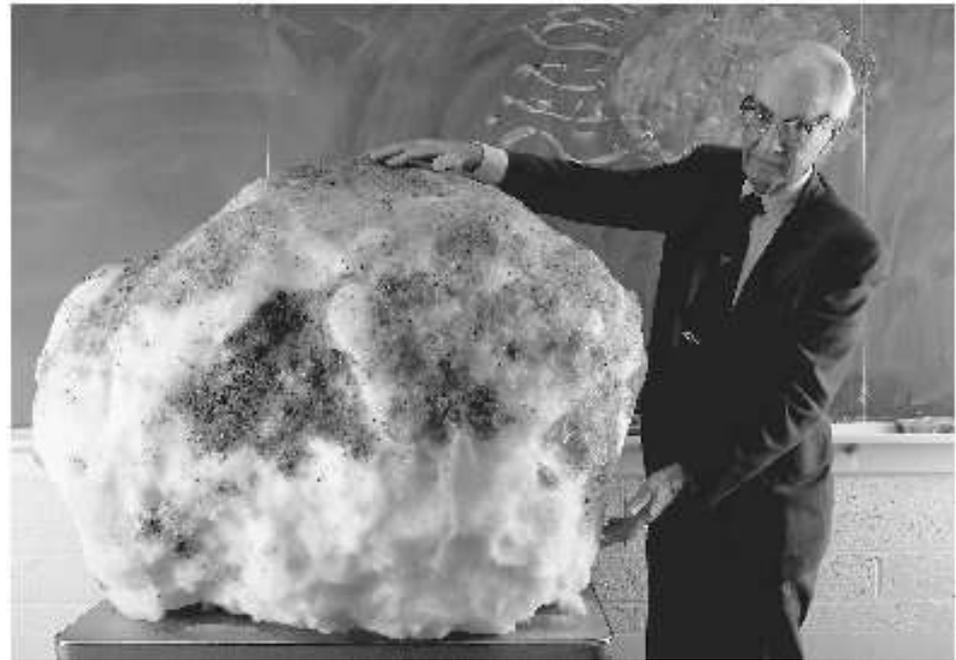
**dust & rocks,**

**carbon,**

**complex carbon compounds**



“Dirty snowball” model  
for the comets was  
first proposed in 1950  
by **Fred Lawrence  
Whipple** (1906 – 2004).



During World War II, Whipple invented a device for cutting tinfoil into chaff to confuse enemy radar tracking Allied aircraft.

From 1955 director of the Smithsonian Astrophysical Observatory, remaining in this post until 1973.

Whipple Observatory on Mount Hopkins in Arizona is named after him.

# The nucleus (central snowball) of comet Halley

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Irregular in shape,  
very dark, and  
very low in  
density.

Emitting jets from  
the sunlit side.



# Comet nuclei are fragile.

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When comet

Shoemaker-Levy 9

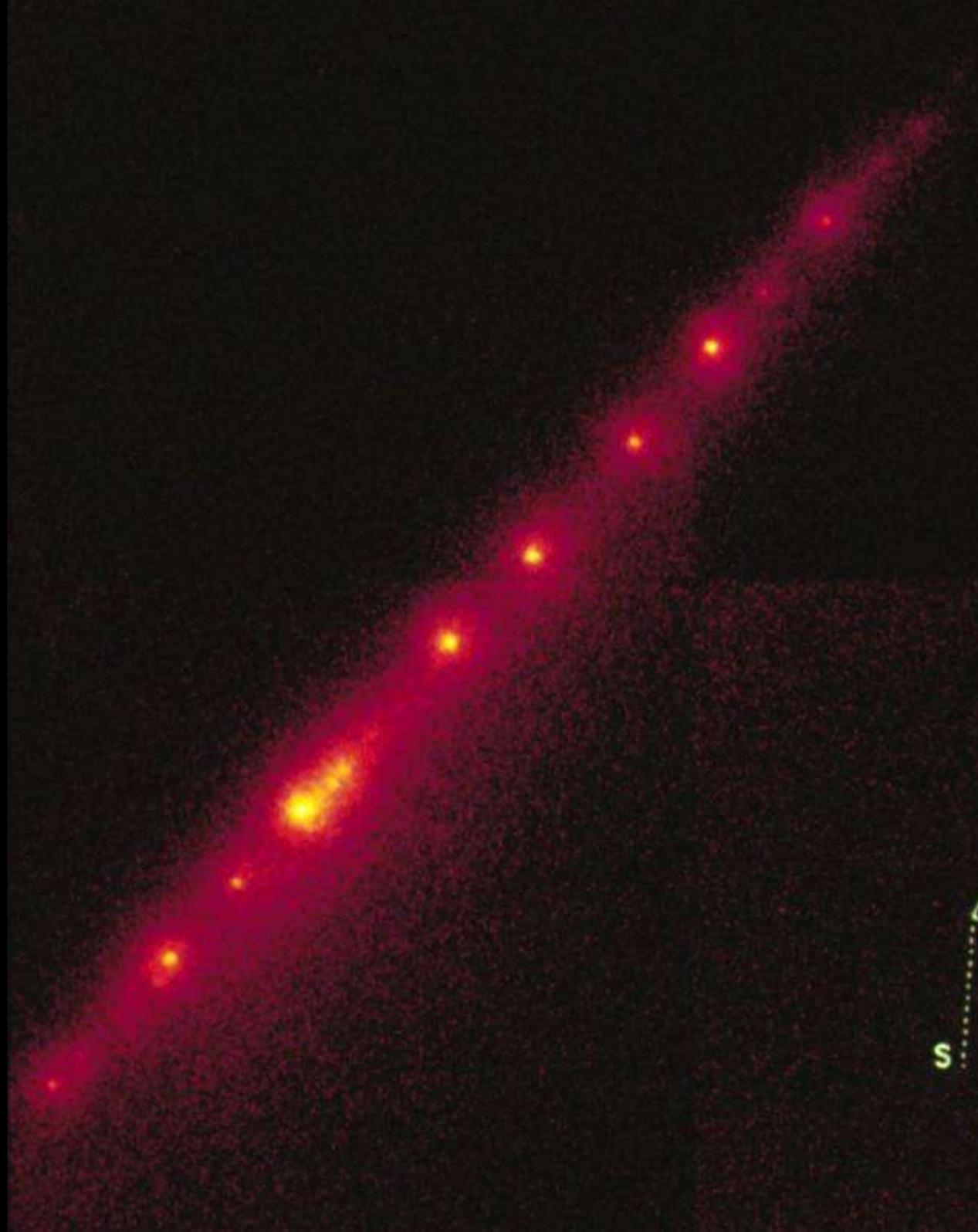
went inside the

Roche lobe of

Jupiter, it was

immediately torn

apart:

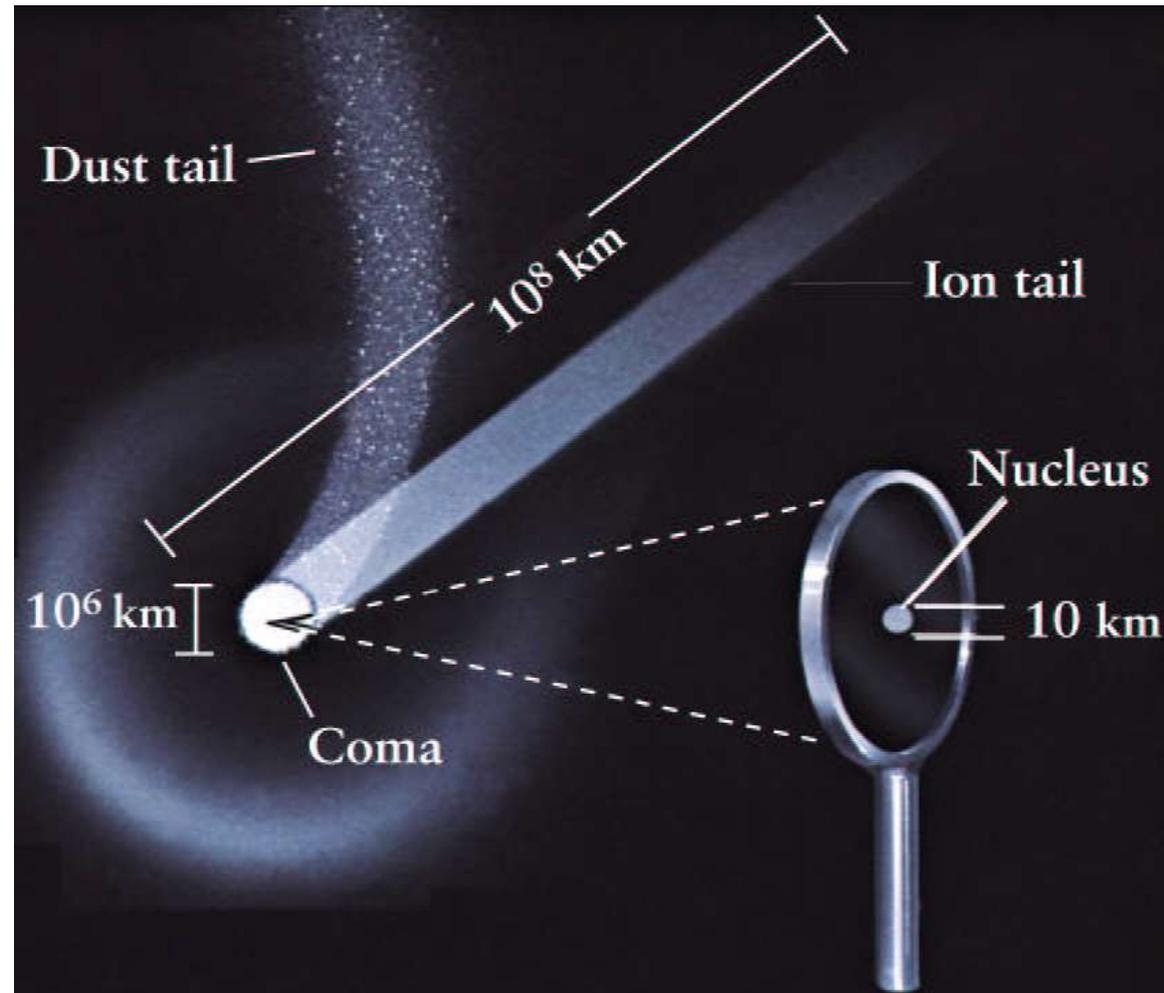


(2) When a comet is close to the Sun, it grows an **ion tail** and a **dust tail**.

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When a comet comes close to the Sun:

- 1) **Nucleus:** snowball  
10 km across.
- 2) **Coma:** gas cloud  
1 million km  
across.
- 3) **Tails:** 100 million  
km long!



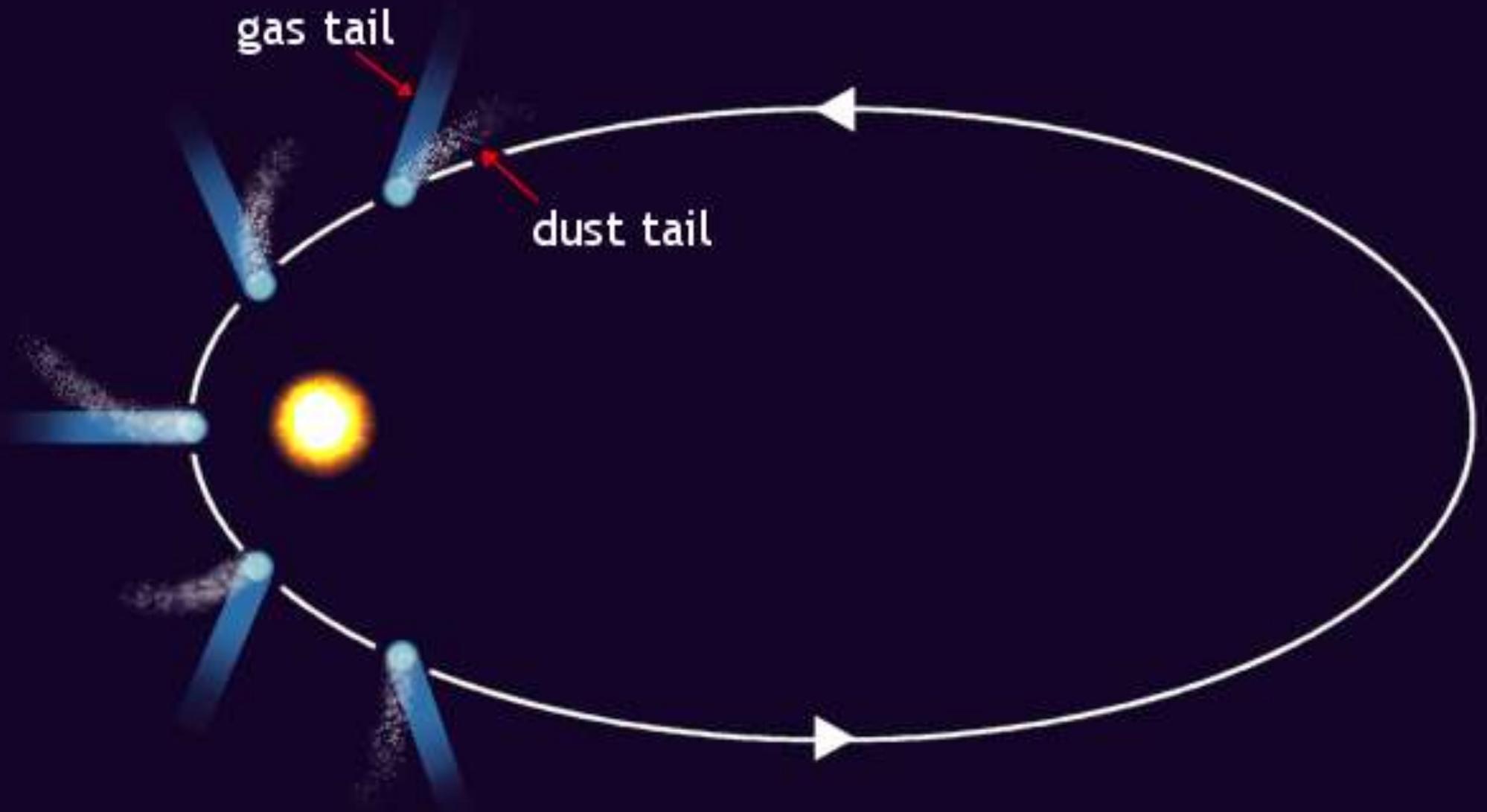
# A tale of two tails



**ION TAIL** (top, blue): ionized gas pushed away from the Sun by the **solar wind**.

**DUST TAIL** (bottom, white): fine dust pushed away from the Sun by **radiation pressure**.

# A tale of two tails



Some comets, like Comet Halley, have orbital periods of less than 200 years.



However, other comets, like Comet Hale-Bopp, have orbital periods of **millions** of years.

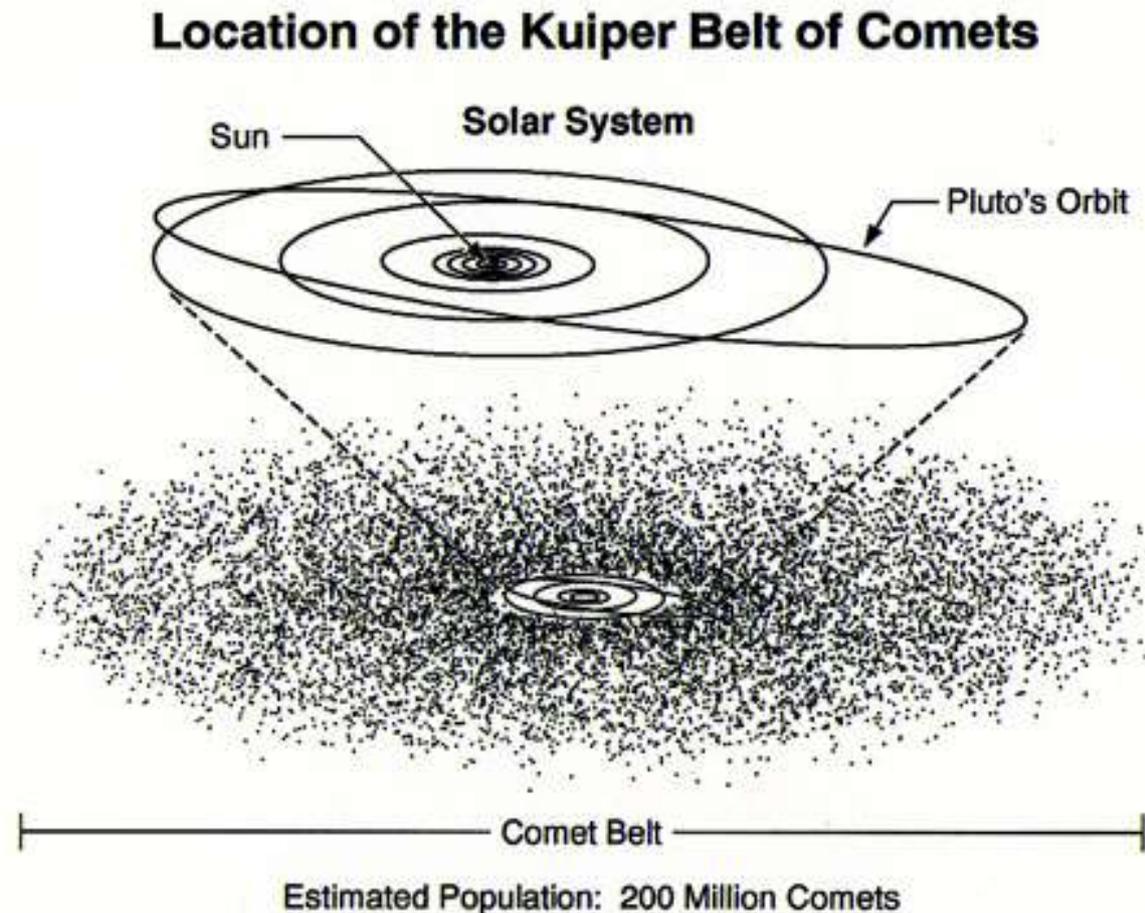


(3) Most comets are in the Kuiper belt or the Oort cloud, far from the Sun.

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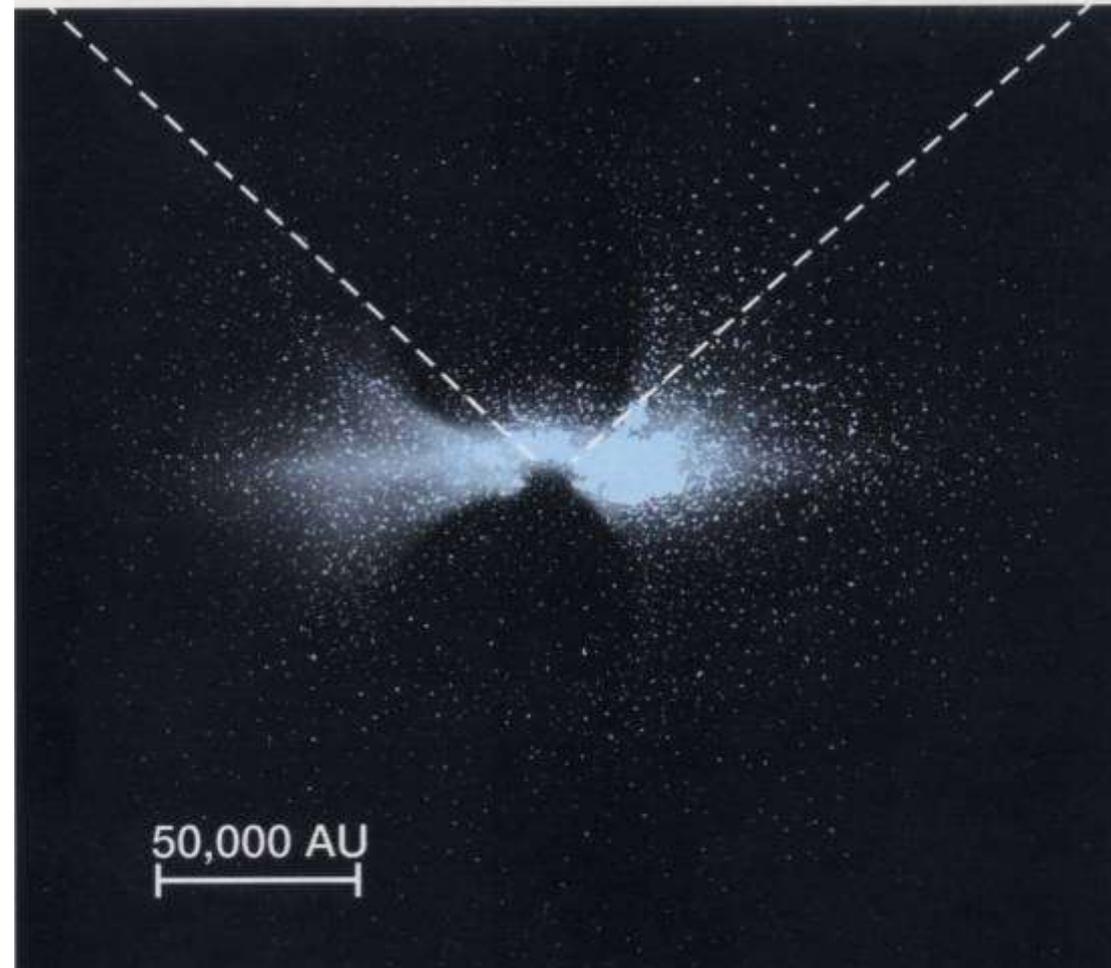
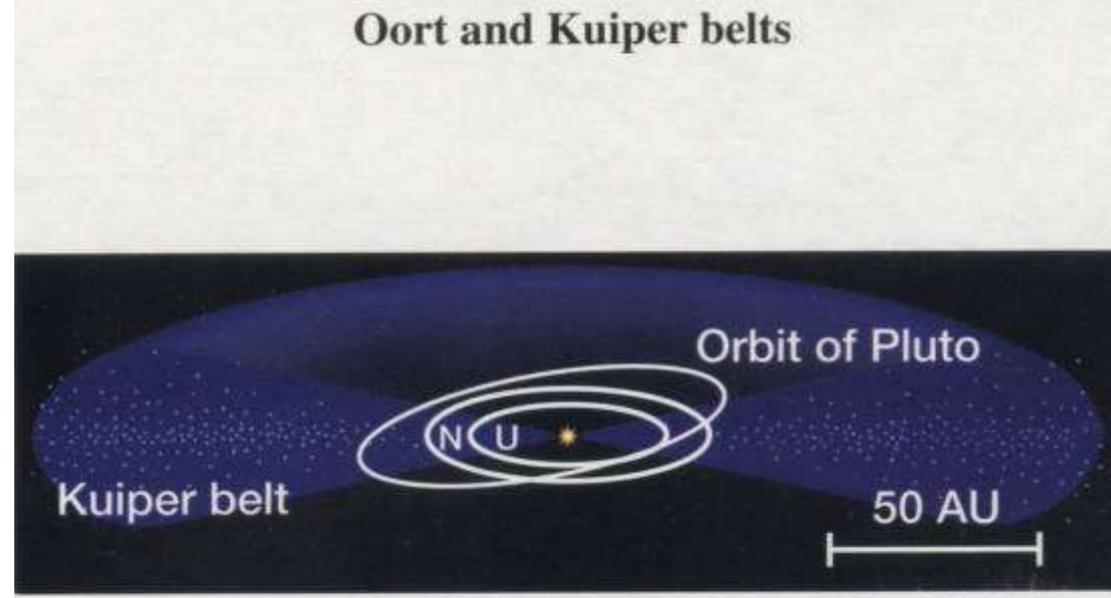
Comets with **short** orbital periods come from the **Kuiper belt**, 30-50 A.U. from the Sun.

We know the Kuiper belt is full of icy objects – we have seen them!



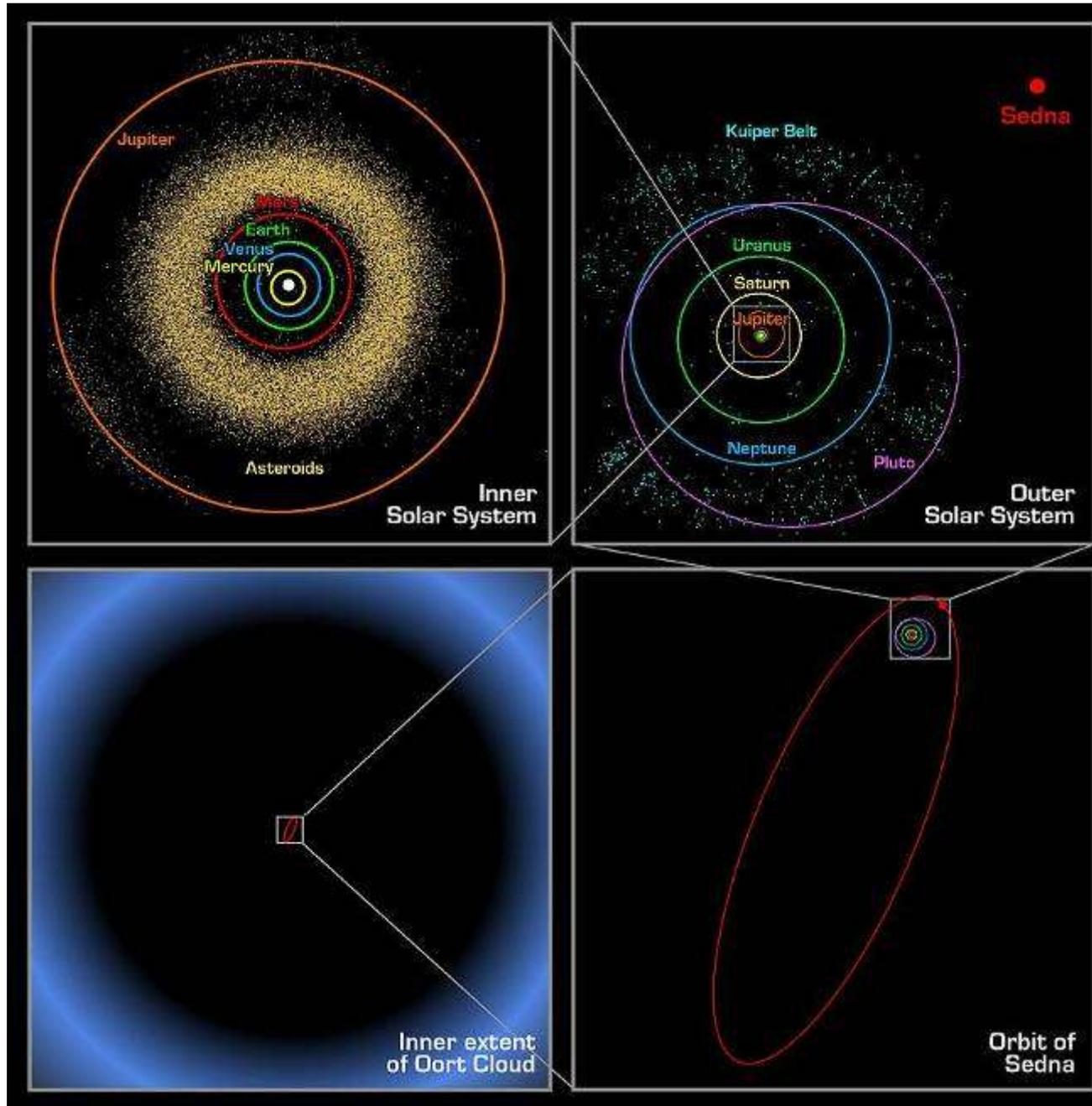
Comets with **long** orbital periods come from the **Oort cloud**, 500-50,000 A.U. from the Sun.

Oort cloud is a swarm of comets that stretches one-fifth the way to the nearest neighboring star.



It is estimated there are several **trillion** comets in the Oort cloud. Total mass of Oort cloud = 100 times mass of Earth.

We only see those rare comets on **extremely** eccentric orbits.

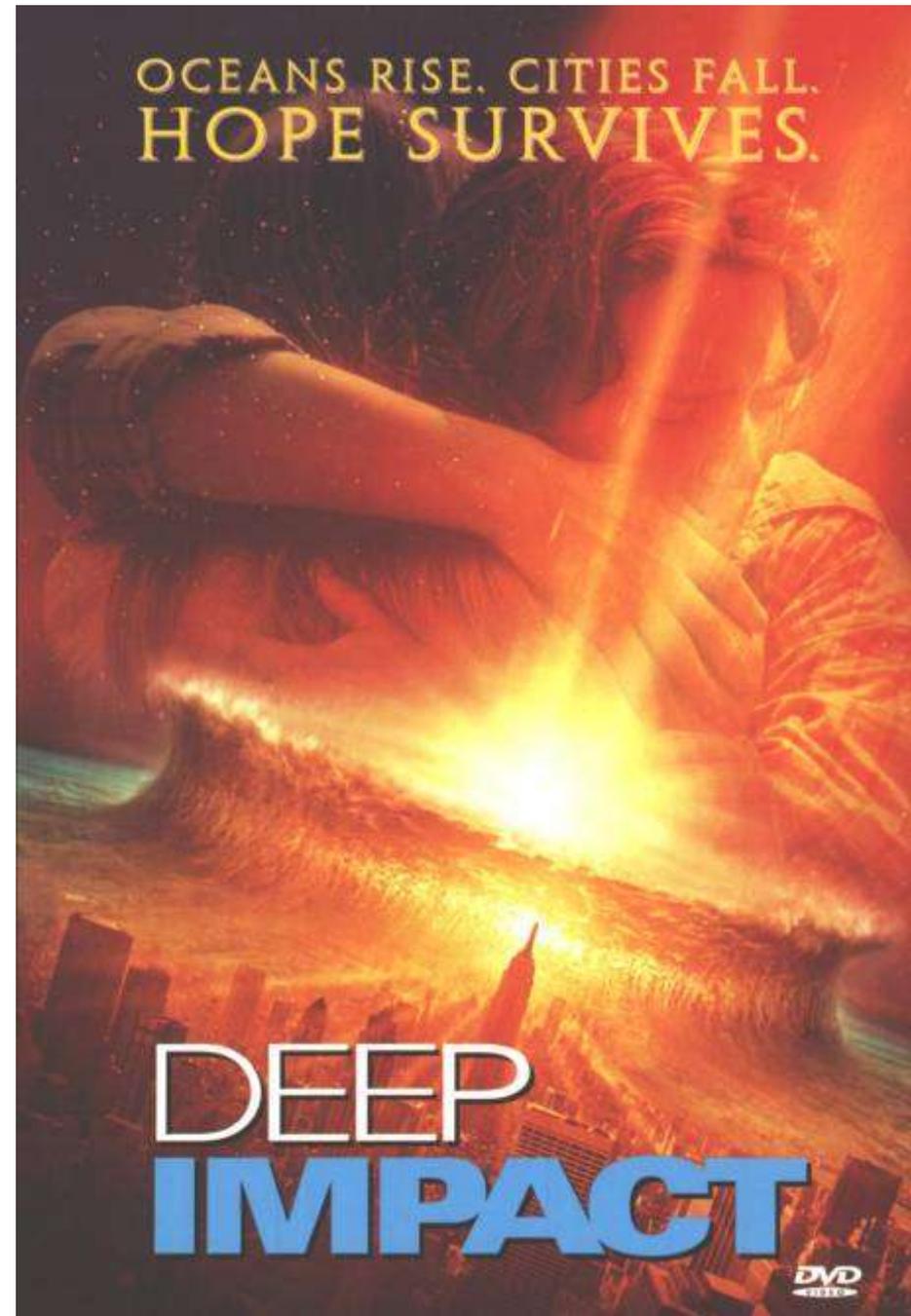


A comet or asteroid packs quite a wallop.

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An object 10 kilometers across, traveling at 10 km/sec, will upon impact release as much energy as a **million** 100 megaton bombs.

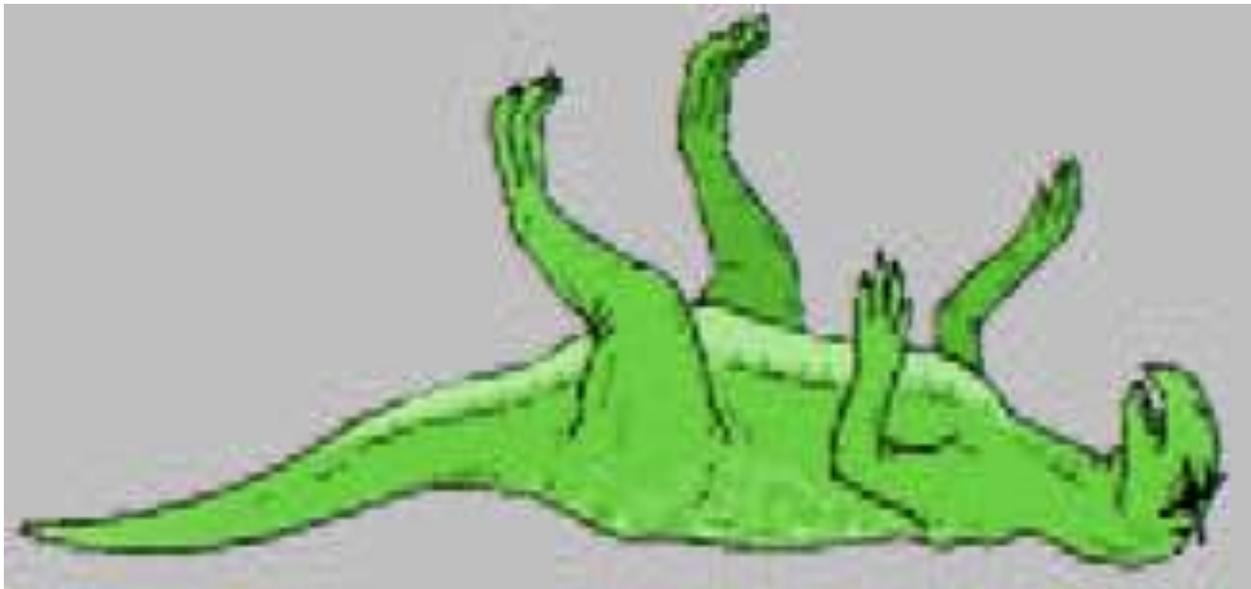
It will blast out a crater at least 100 kilometers across.



(4) A comet or asteroid impact may have caused the extinction of the dinosaurs.

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In the Cretaceous mass extinction, 65 million years ago, 70% of all species were killed off ... including all dinosaurs. The extinction was rapid, geologically speaking.



Current favorite explanation:  
**COLLISION HYPOTHESIS**

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A comet or asteroid struck the Earth 65 million years ago, triggering the mass extinction.

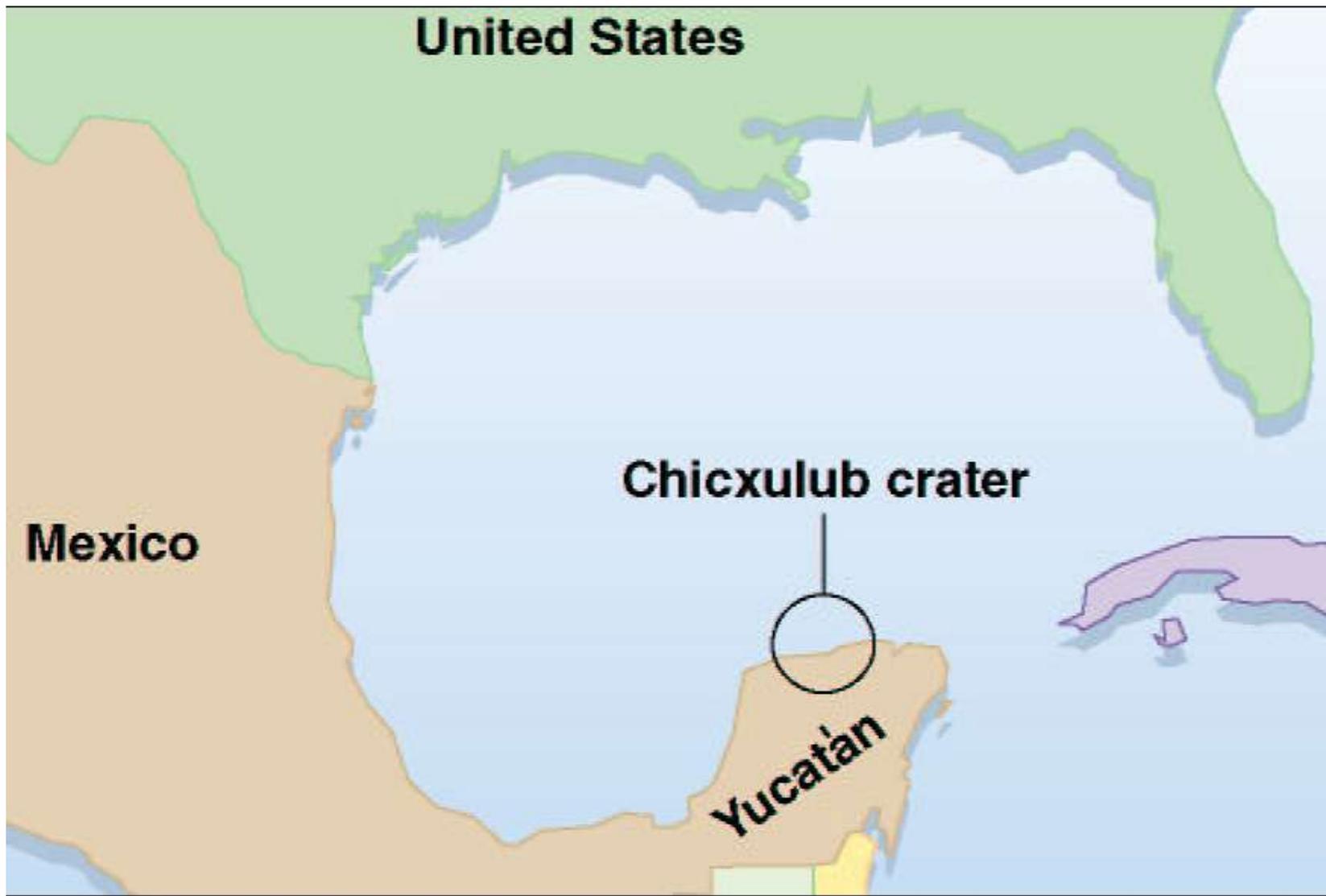
Testing the **Collision**

**Hypothesis:**

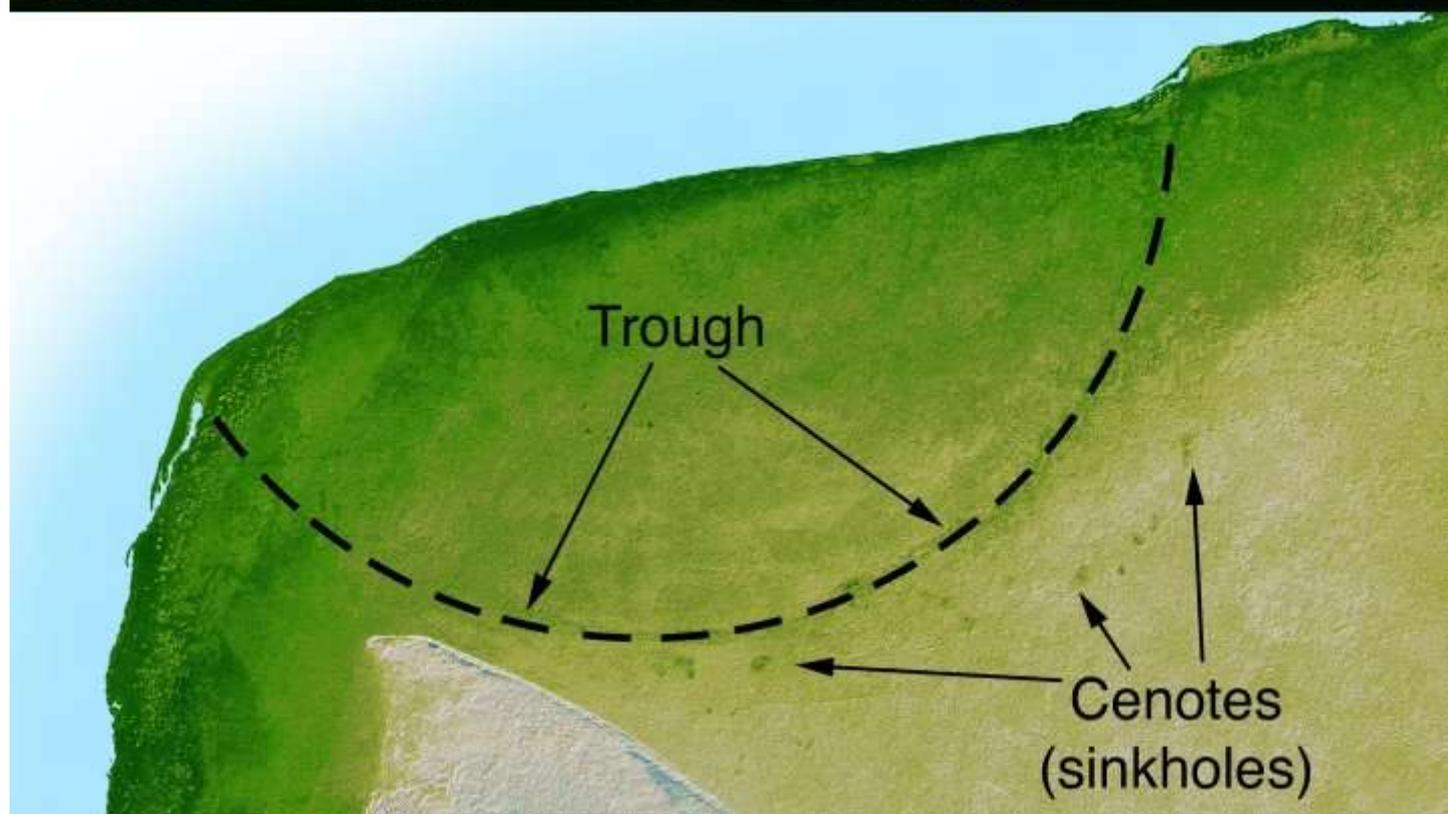
Look for a crater  
65 million years  
old, as least  
100 km across.



Recent discovery: The Chicxulub impact crater,  
180 km across, buried under thick sediment.  
Estimated age: 64.98 million years.



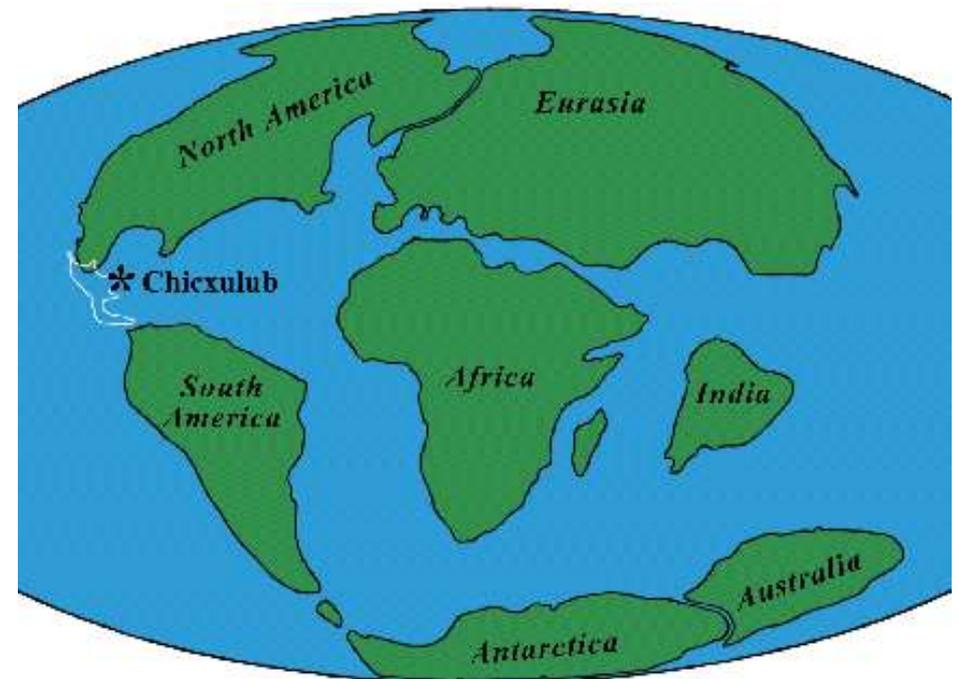
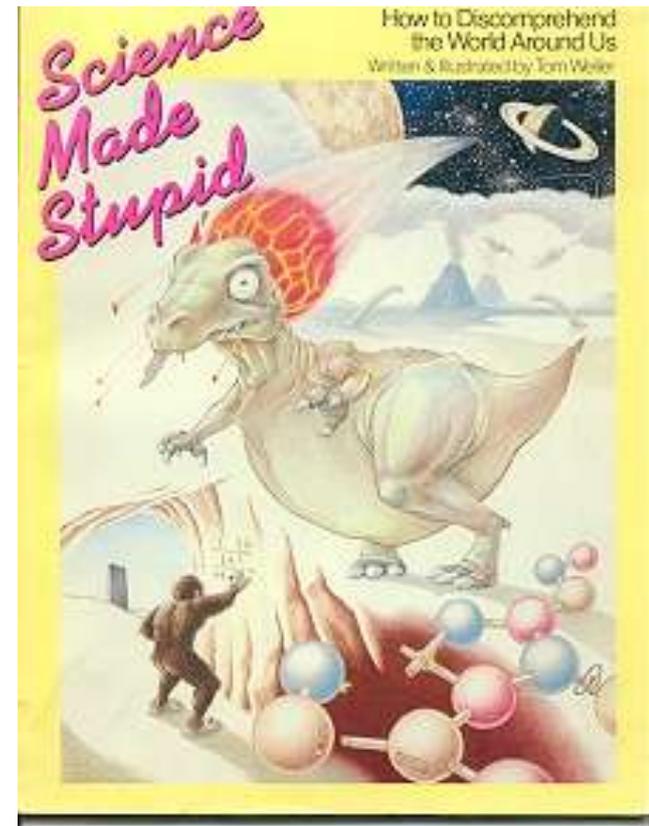
Radar  
topography  
reveals the  
180 kilometer  
(112 mile)  
wide ring of  
the crater.



Did the impact cause the extinction, or was it just a coincidence?

Few dinosaurs were hit on the head by the impact. More were killed by the blastwave.

To kill **all** the dinosaurs, you need an **indirect** method.



## **Killing Method:**

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Colliding object ejects dust into atmosphere

↓  
Months of darkness and cold

↓  
Death of plants

↓  
Starvation of herbivores

↓  
Starvation of carnivores

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(Not to mention the tsunamis, forest fires, acid rain, and other unpleasant events.)



## Few closing questions:



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- 1) Why is the ion tail blue?
  - 2) Why is the dust tail white?
  - 3) Why is the ion tail straight?
  - 4) Why is the dust tail curved?
  - 5) The **Tunguska event**: June 30, 1908.
  - 6) Why do we suspect the presence of the Oort cloud?