The Slowly Fading Light Echo Around Type Ia Supernova 2009ig

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University of Notre Dame Astrophysics Seminar

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Crash Course on Light Echoes

What is a light echo?

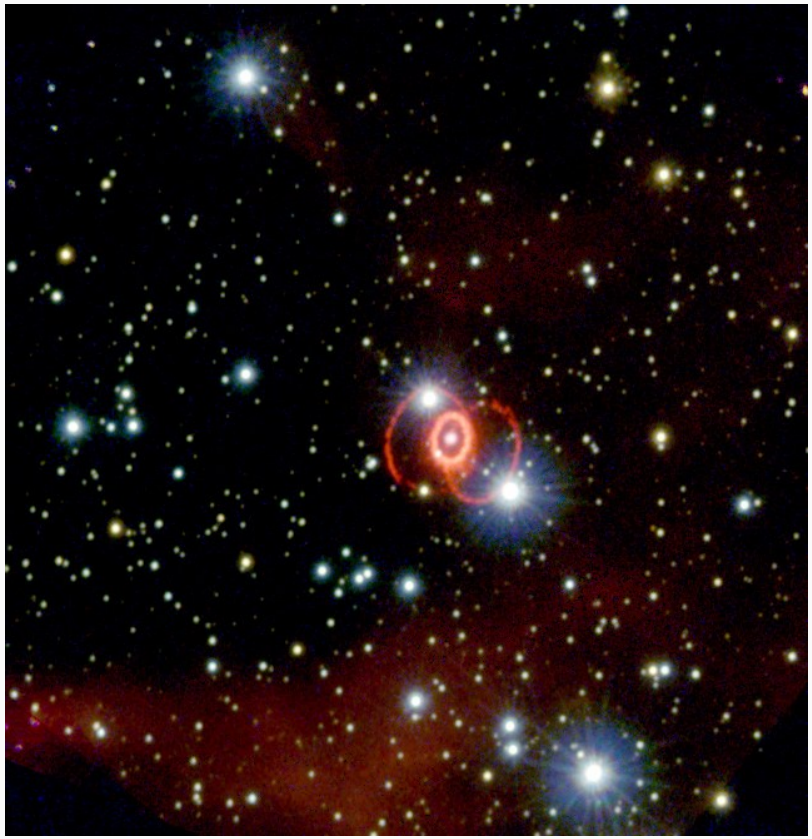

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Image credit - ESA/Hubble

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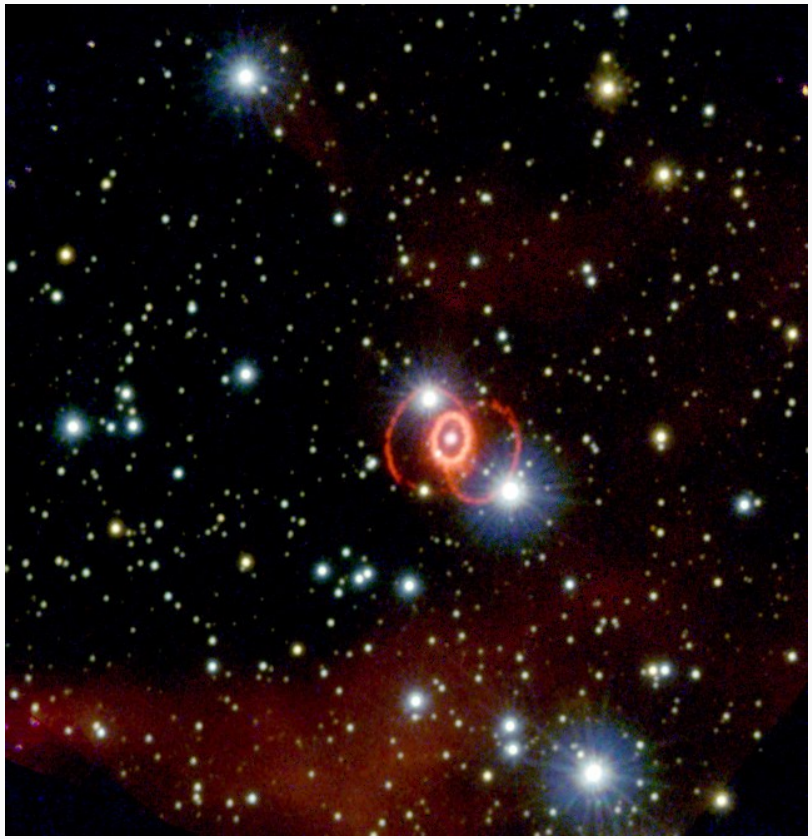

- Light is scattered by dust into our line of sight
- NOT caused by emission

Image credit - ESA/Hubble

Geometry of Light Echoes

- Ellipsoid with event at one focus and observer at the other

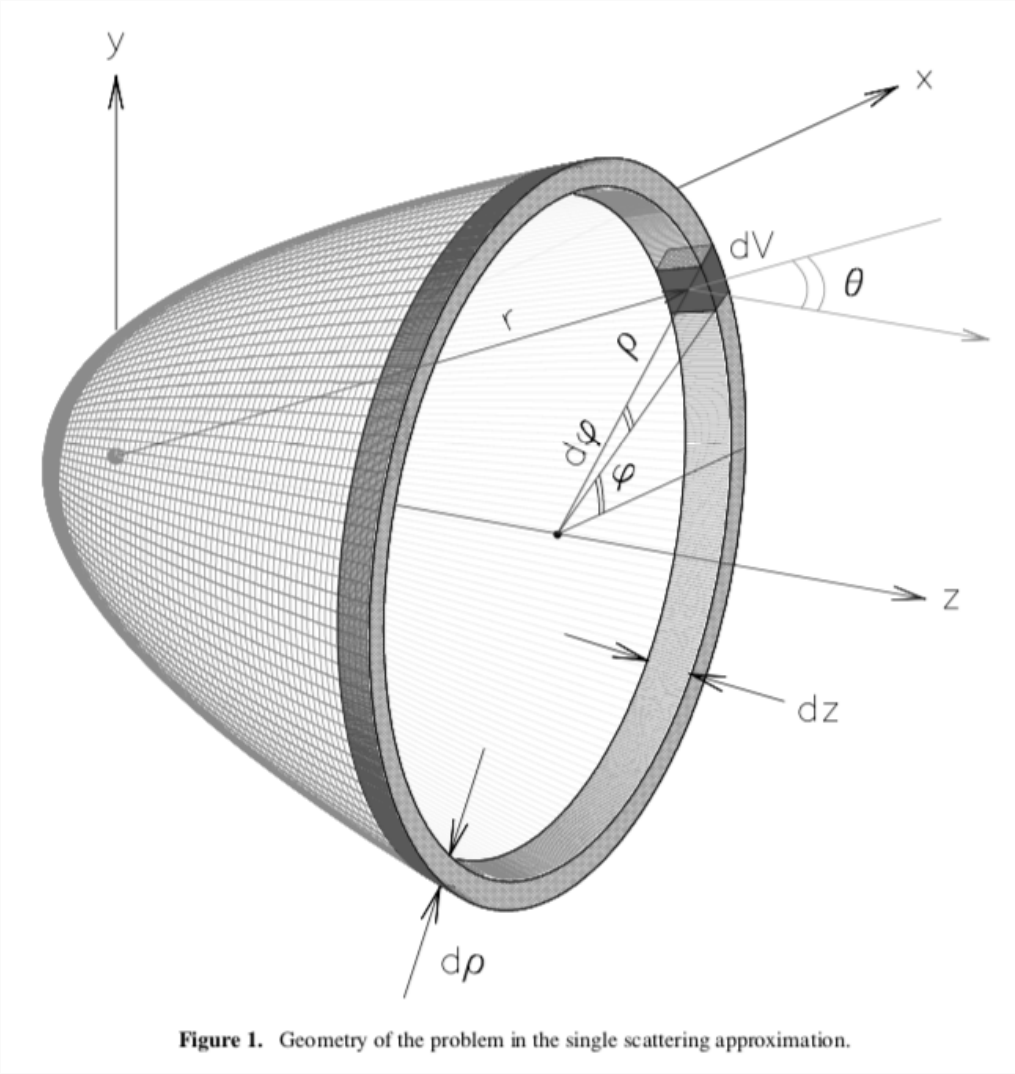

Figure 1. Geometry of the problem in the single scattering approximation.

Image credit - Patat 2005

Geometry of Light Echoes

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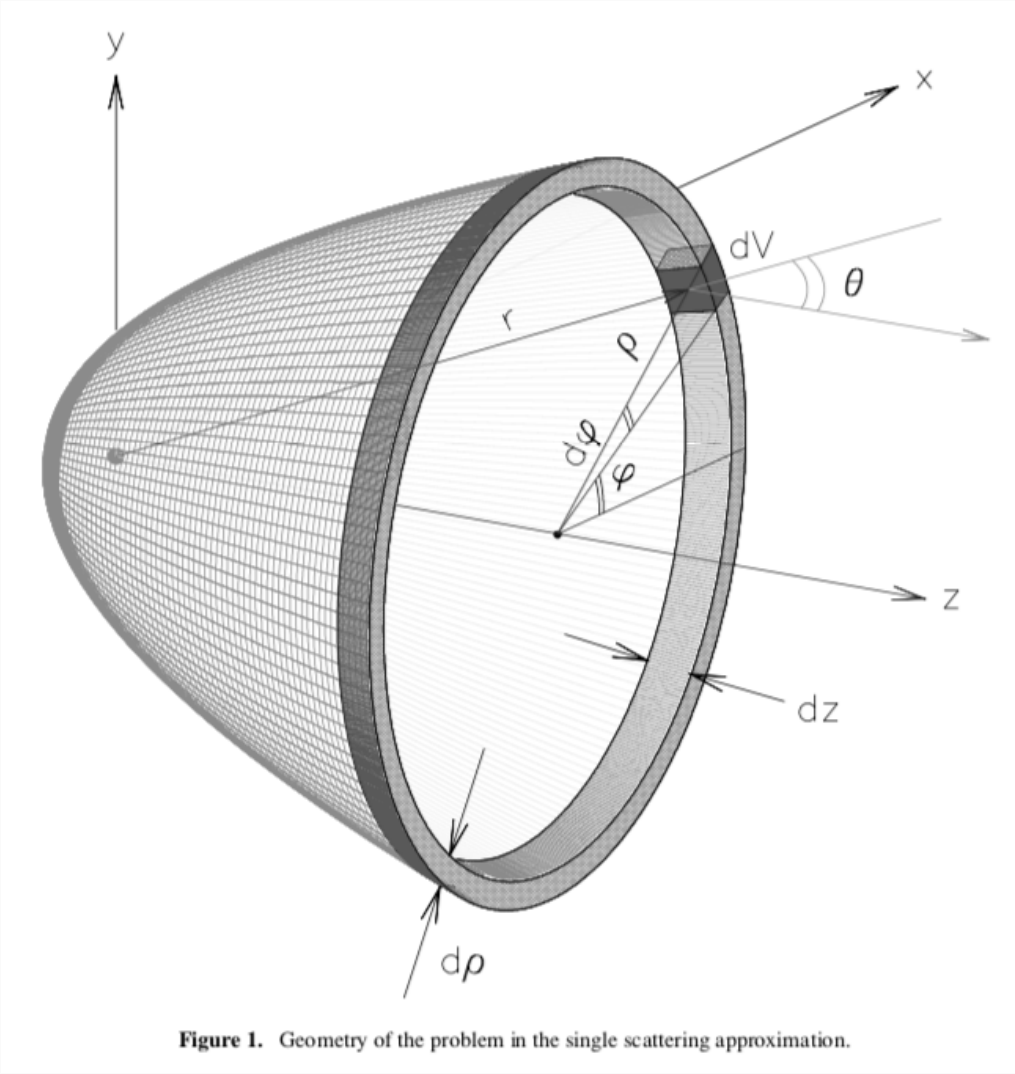
- Approximated as a paraboloid (distance very large)



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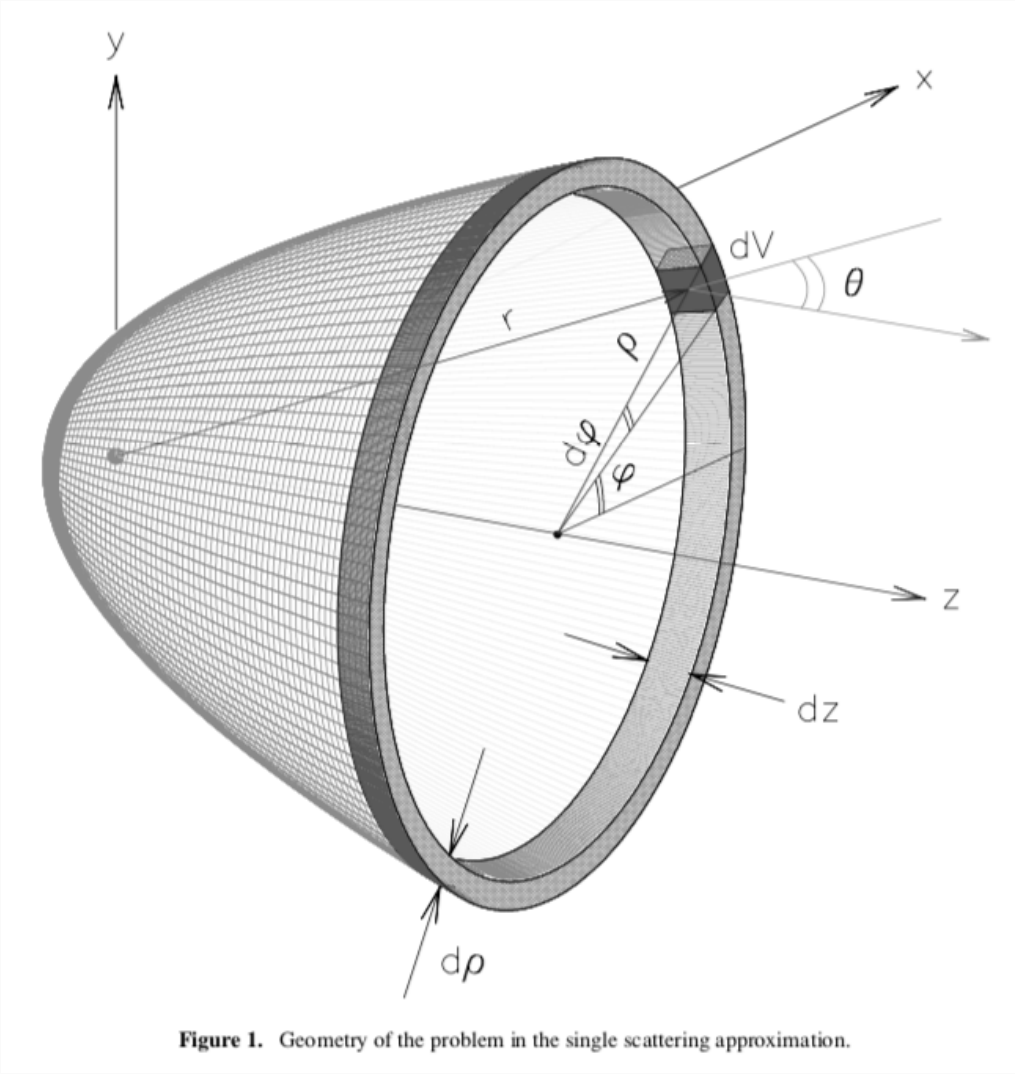
Geometry of Light Echoes

- Ellipsoid with event at one focus and observer at the other
- Approximated as a paraboloid (distance very large)
- Light from all points on paraboloid take equal time to arrive



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Superluminal expansion?

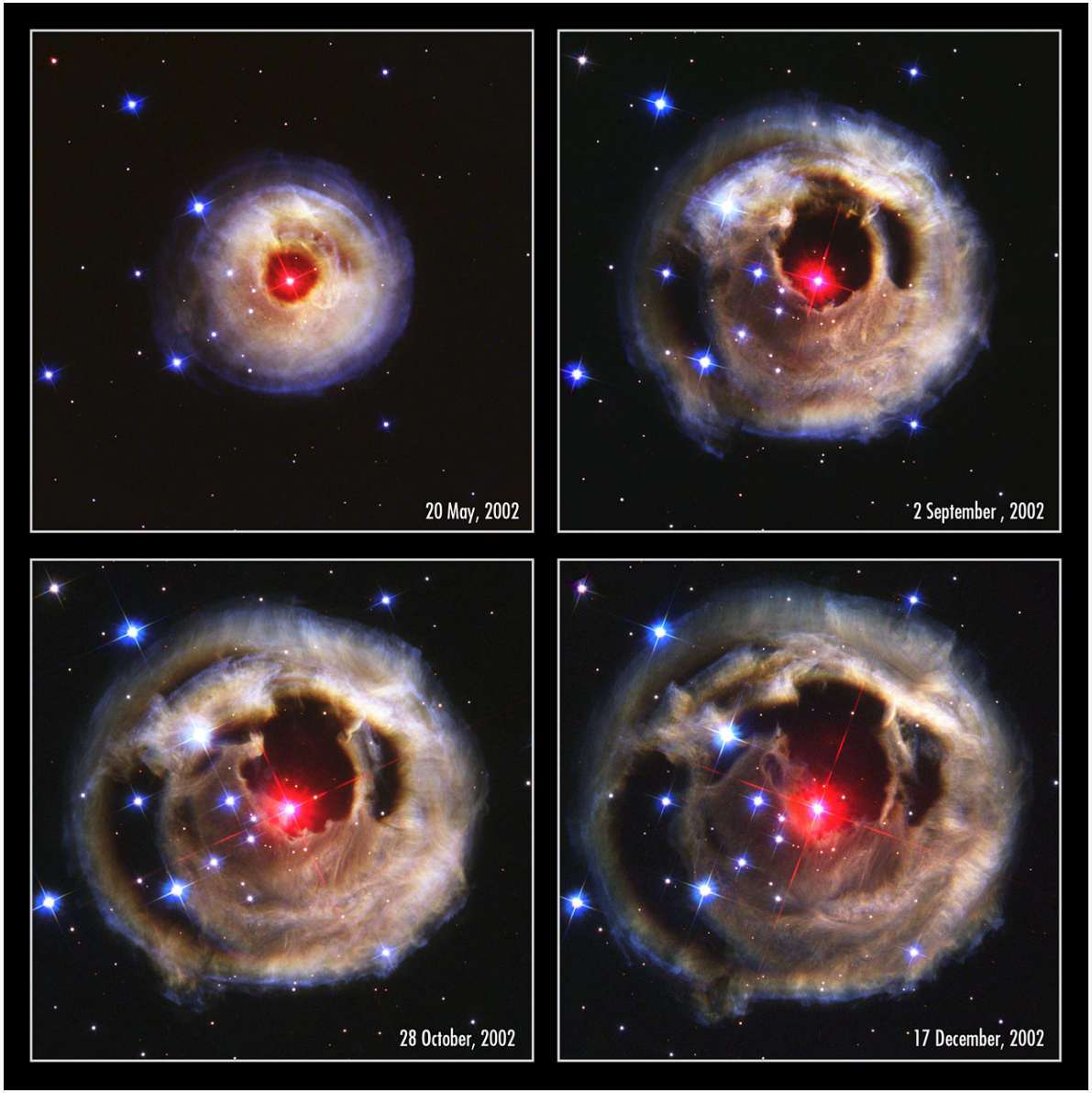

Image credit - ESA/Hubble, STScI

What can light echoes tell us about supernovae?

- 3-D picture of the local dust distribution

Image credit - S. Heinz et al.

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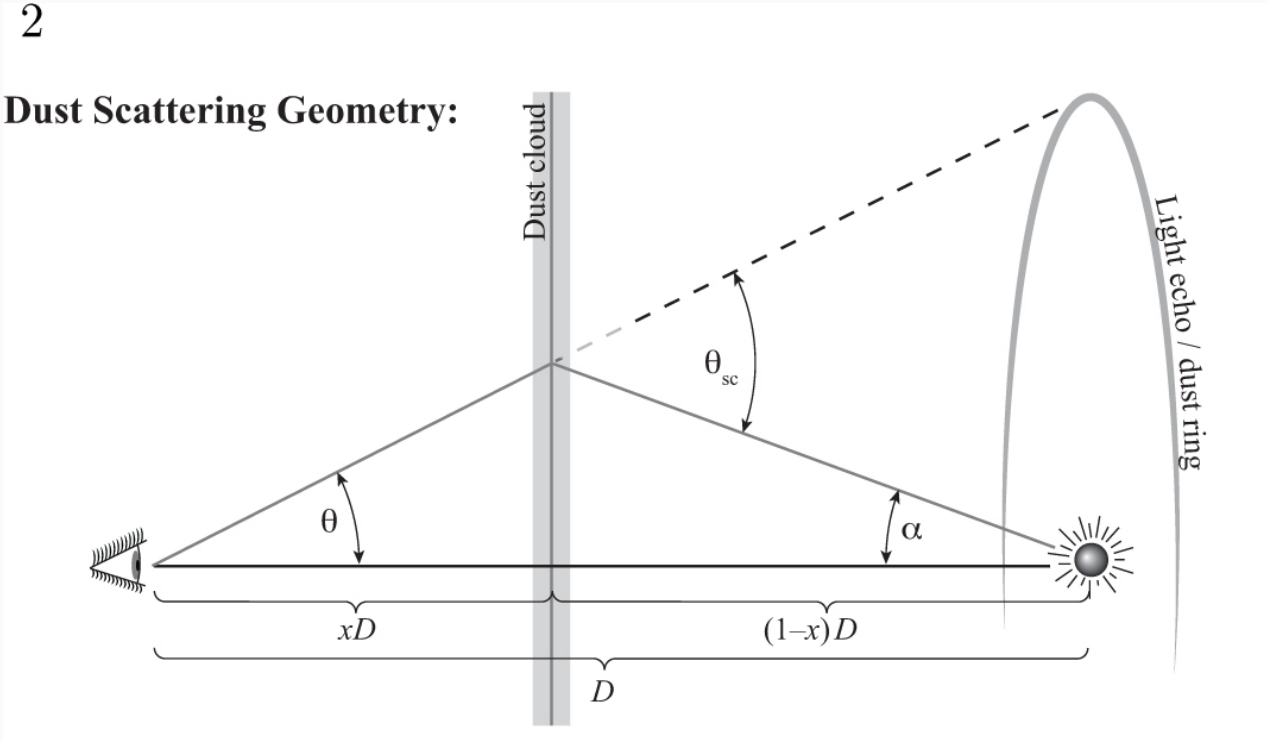
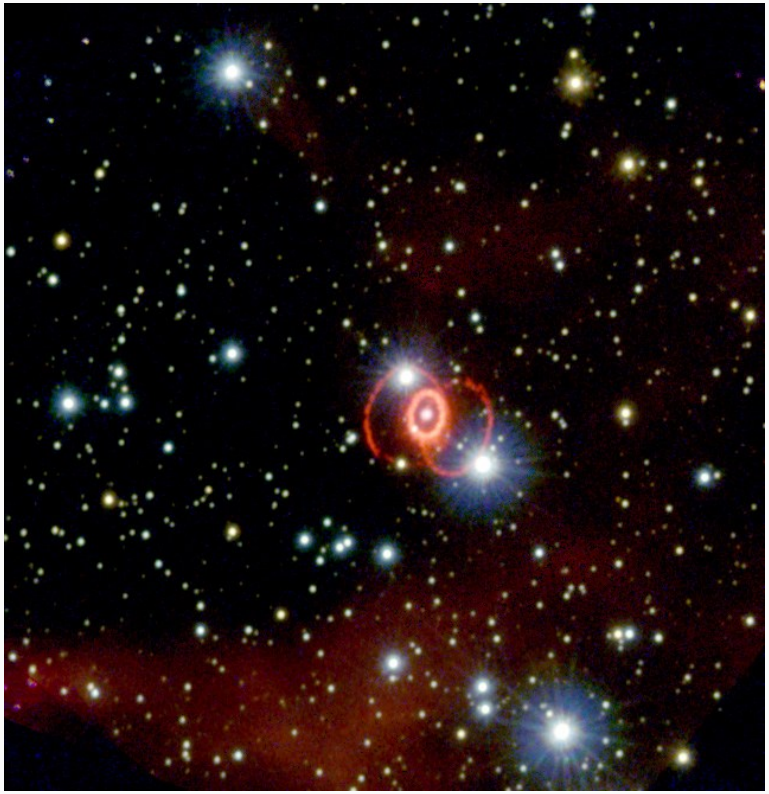


Image credit - S. Heinz et al.

3-D Shape of SN 1987A Light Echo



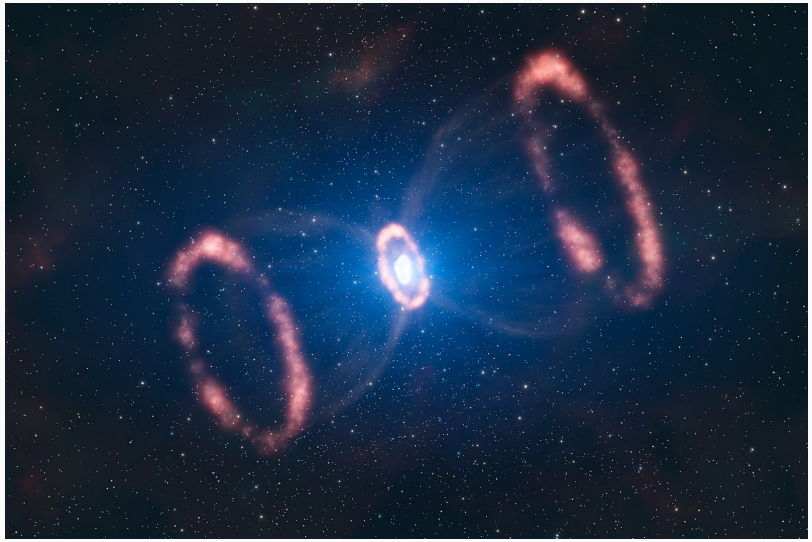


Image credit - ESA/Hubble, ESO

Which supernovae have light echoes?

- Generally found around core-collapse supernovae

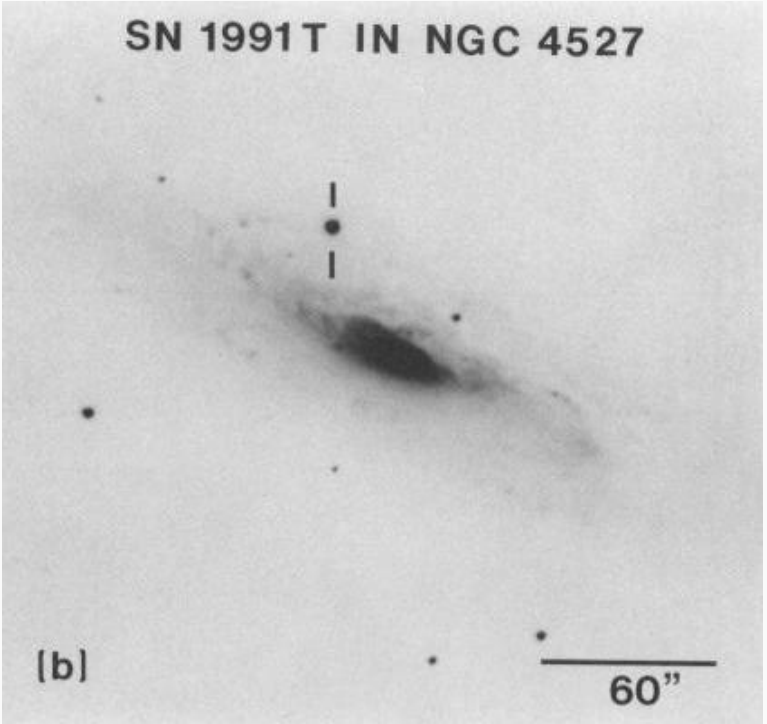


Image credit - Filippenko et al. 1992

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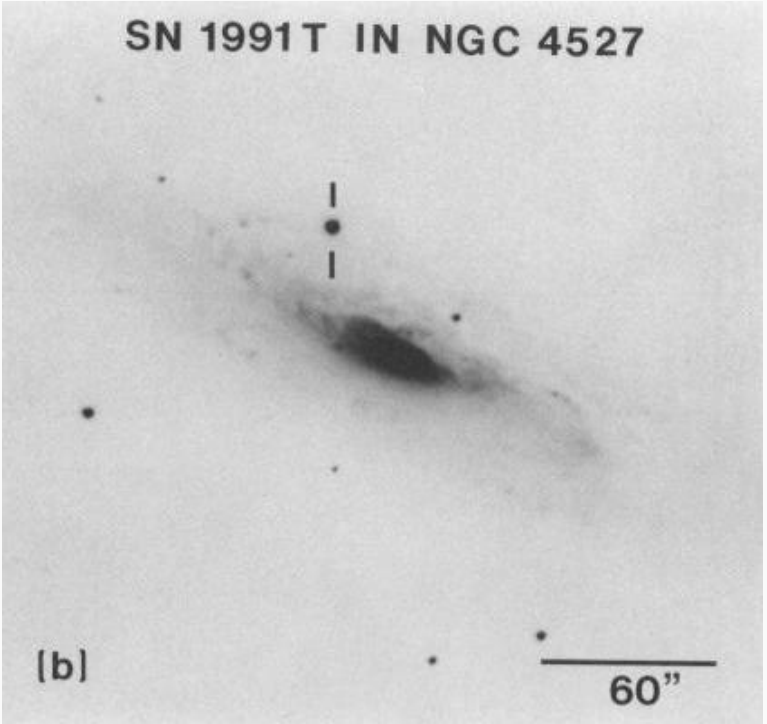
- Generally found around core-collapse supernovae
- Light echoes do occur around SNe Ia, but are rare



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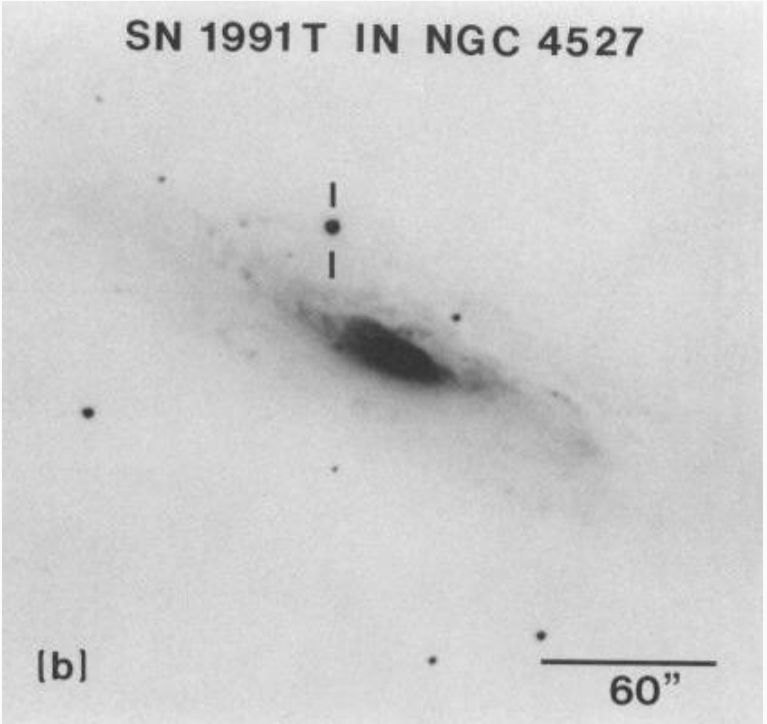
Which supernovae have light echoes?

- Generally found around core-collapse supernovae
- Light echoes do occur around SNe Ia, but are rare
- Know SNe Ia light echoes: 1991T, 1995E, 1998bu, 2006X, 2007af, 2009ig, 2014J, 2012cg?



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Why do Type Ia Supernova Light Echoes Matter?

Implications?

Type Ia supernovae are used as standard candles for cosmology

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- Properties of SNe Ia are related to their environment

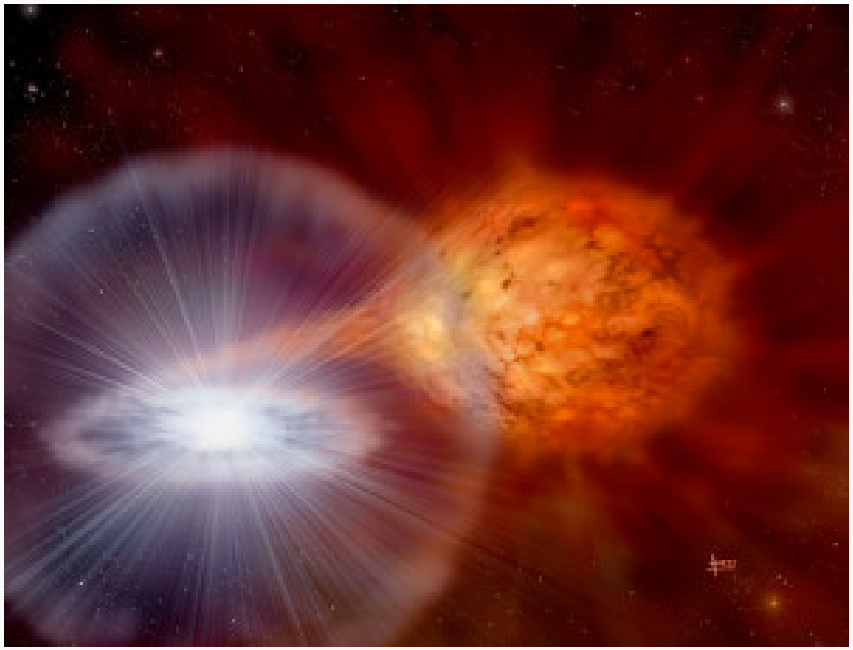
Implications?

Type Ia supernovae are used as standard candles for cosmology

- Properties of SNe Ia are related to their environment
- Hints at different progenitors

Single vs. Double Degenerate Progenitors

- One white dwarf, one main sequence/giant star
- Material accretes from companion onto white dwarf



- Two white dwarfs; combined mass $> 1.4 M_{\odot}$
- Close binary that eventually merges

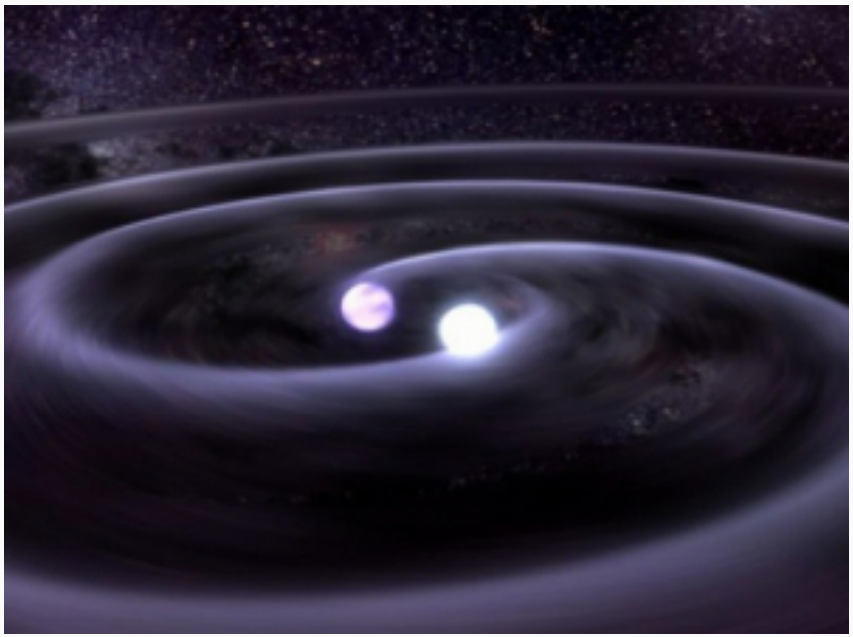
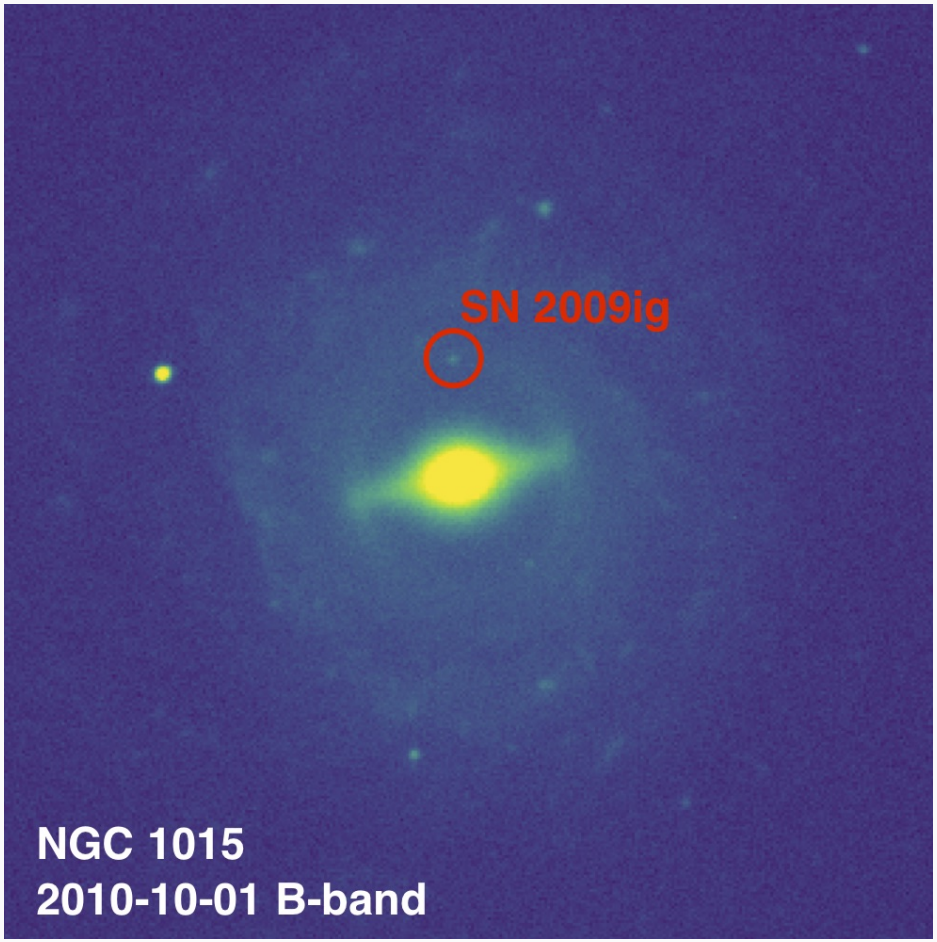


Image credit - *Left:* D. A. Hardy/AstroArt.org; *Right:* GSFC/D. Berry

SN 2009ig Observations & Results

Why is SN2009ig interesting?



- Normal type Ia supernova
- Peak magnitude V $= 13.5$
- Nearby in NGC 1015 ($z = 0.0088$)
- Practically no host galaxy extinction ($A_V = 0.01 \pm 0.01$)
- Used in H_0 measurements!

Late-time Photometry

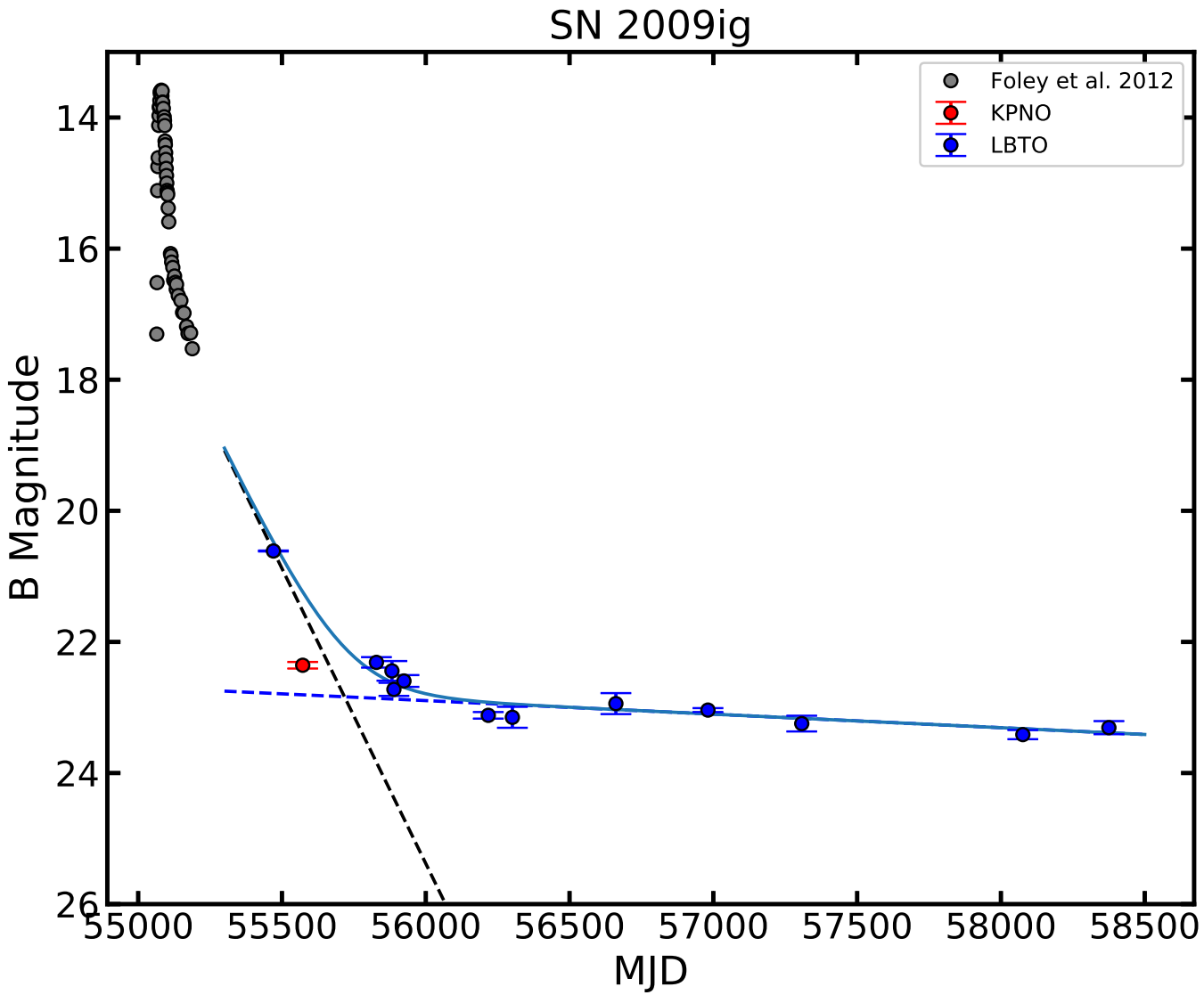
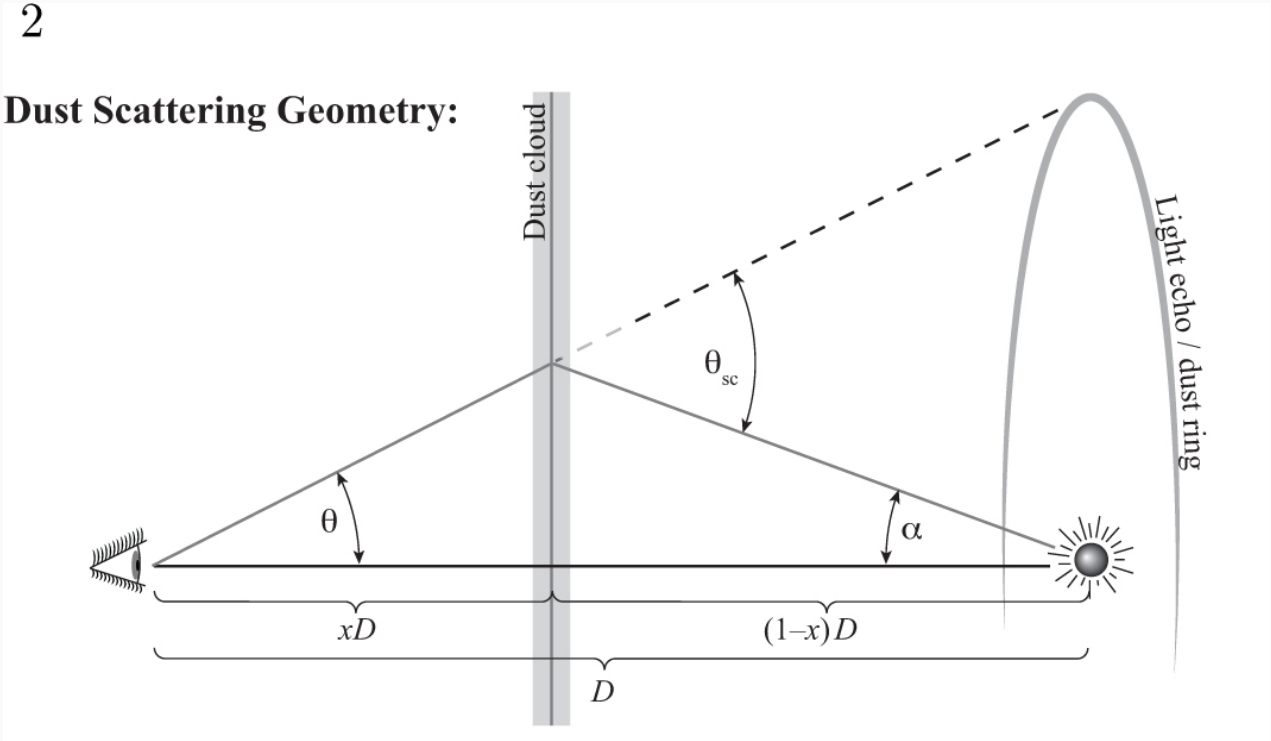


Image credit - C. M. Wood

Potential geometry?



- Sheet of dust with hole?
- How local is the dust?
- Need to resolve light echo to determine geometry!

Image credit - S. Heinz et al.

Comparison to Model & Other Light Echoes

- Compare magnitude difference between peak and echo to estimate of extinction
- SN2009ig is very 1991T-like

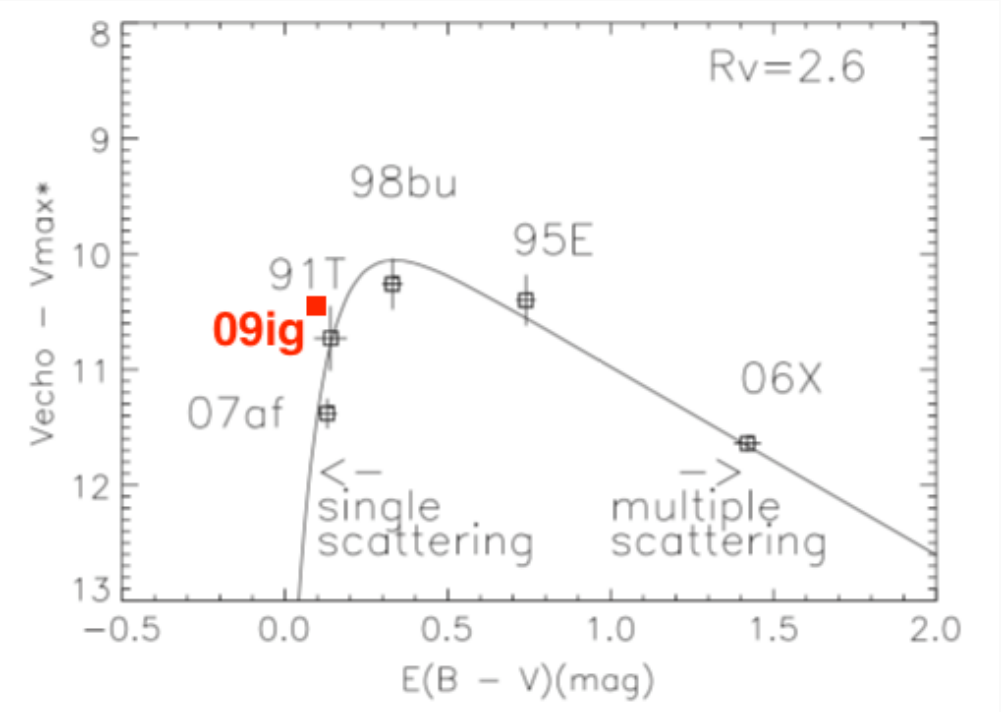


Image credit - Drozdov et al. 2015

Future Work

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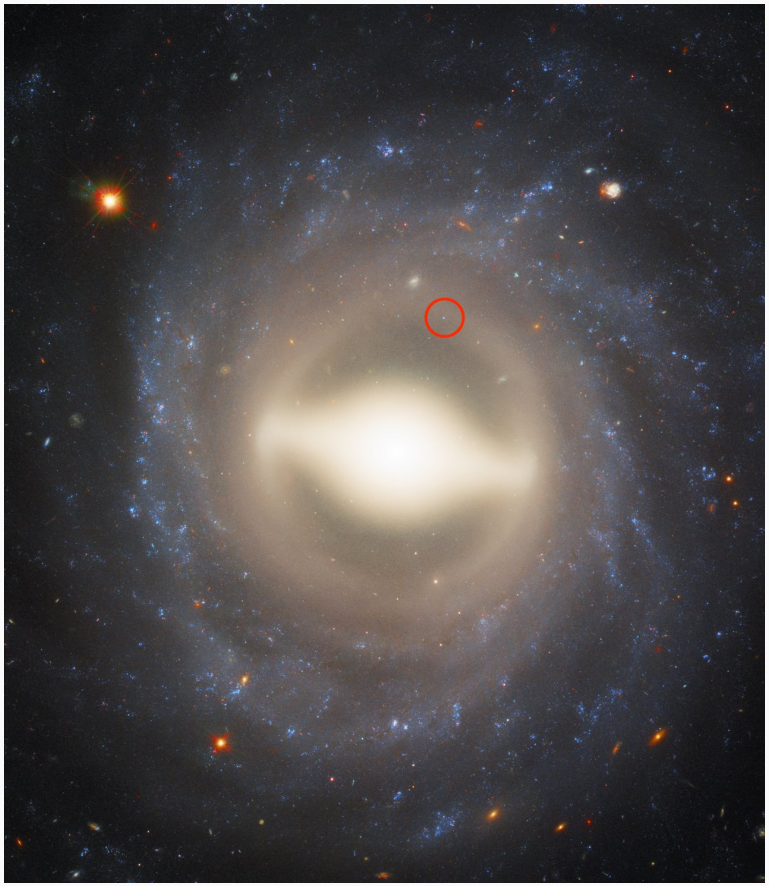

- Resolved in archival Hubble data?

Image credit - ESA/Hubble & NASA, A. Riess

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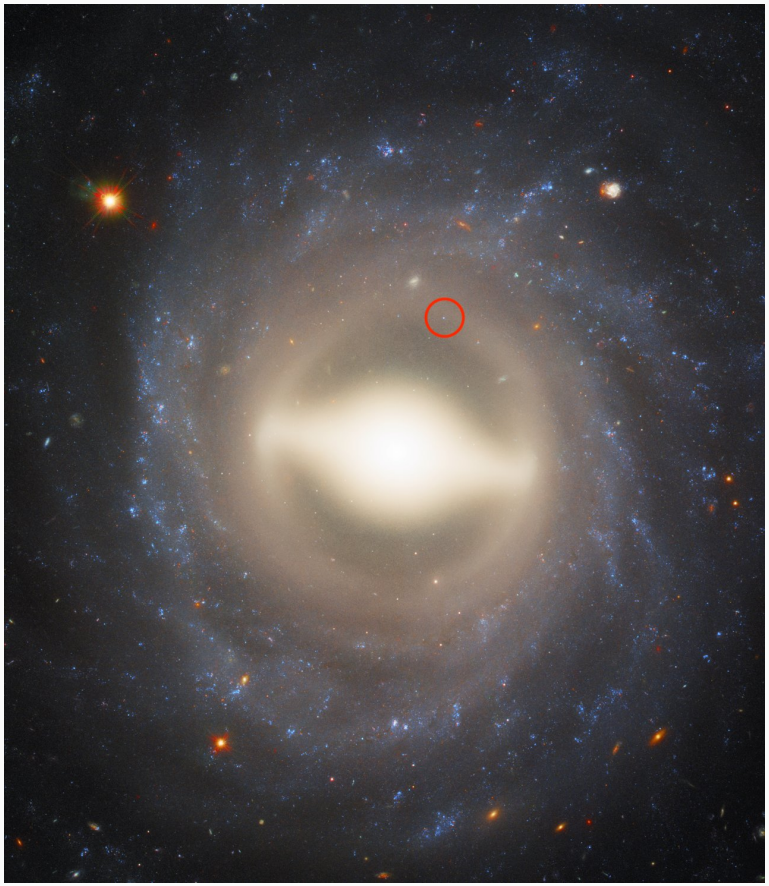

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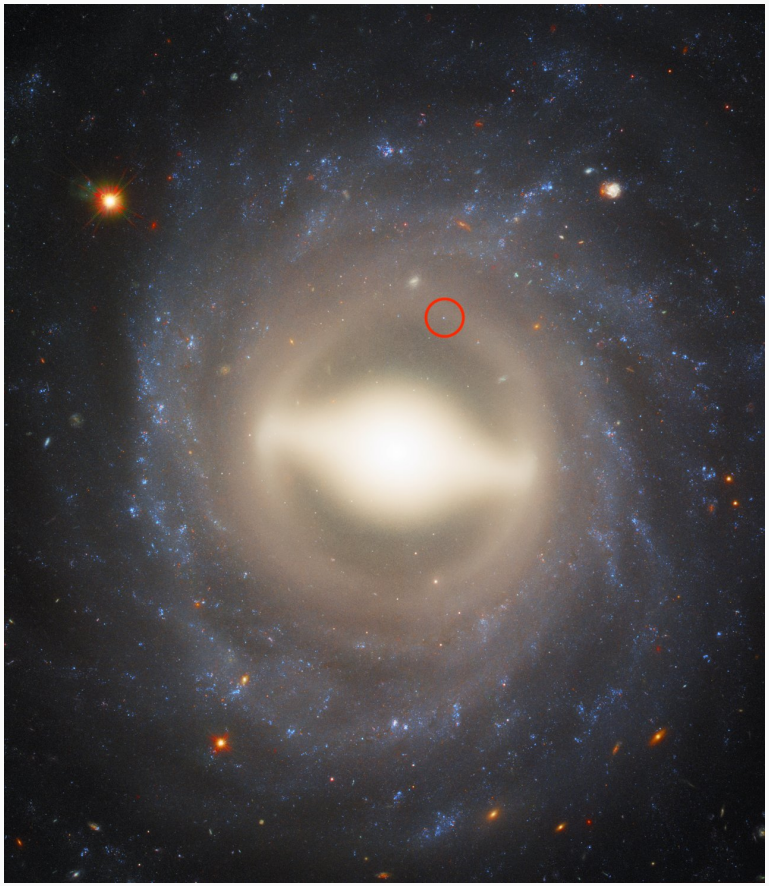

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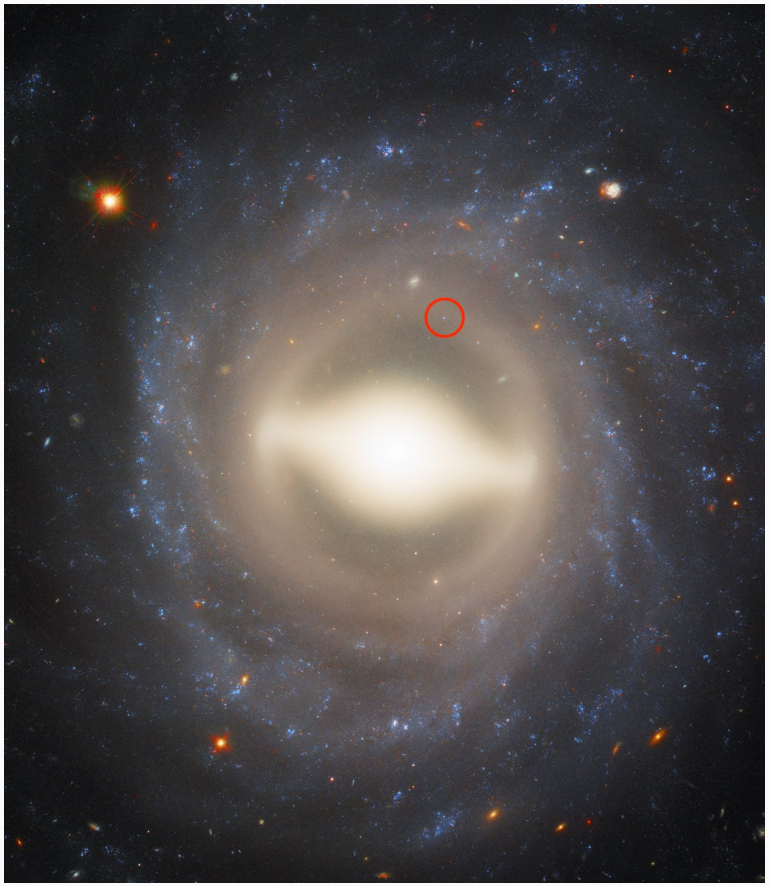

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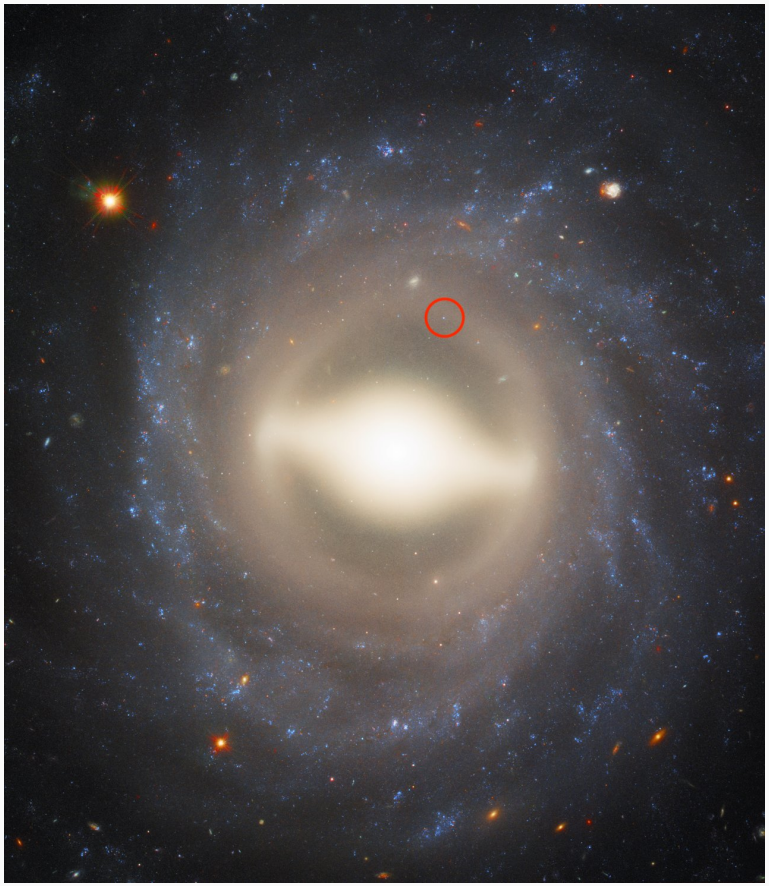

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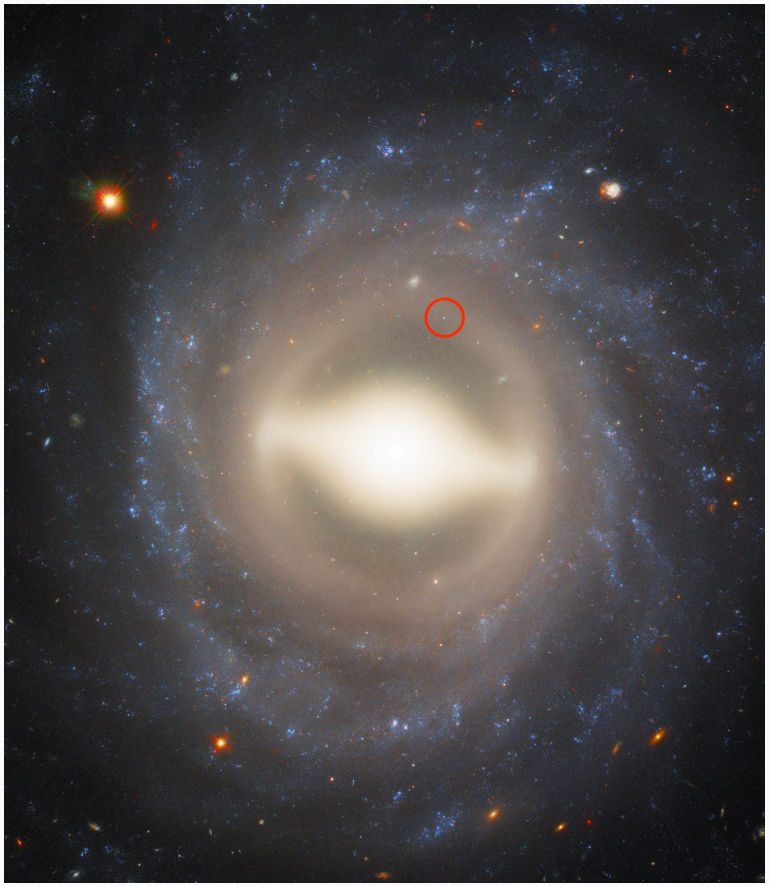

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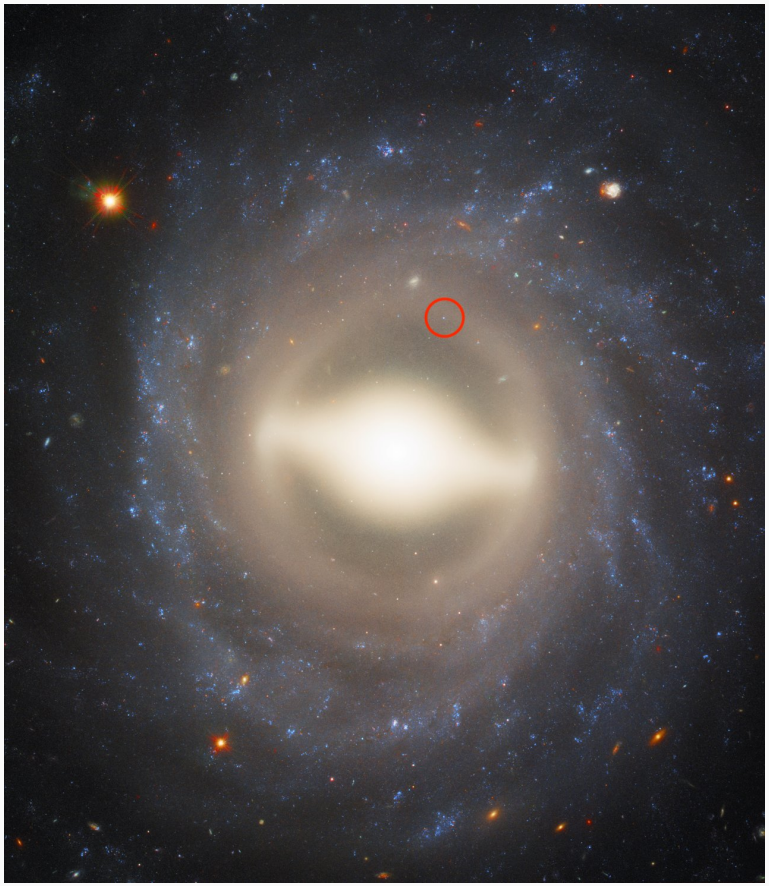

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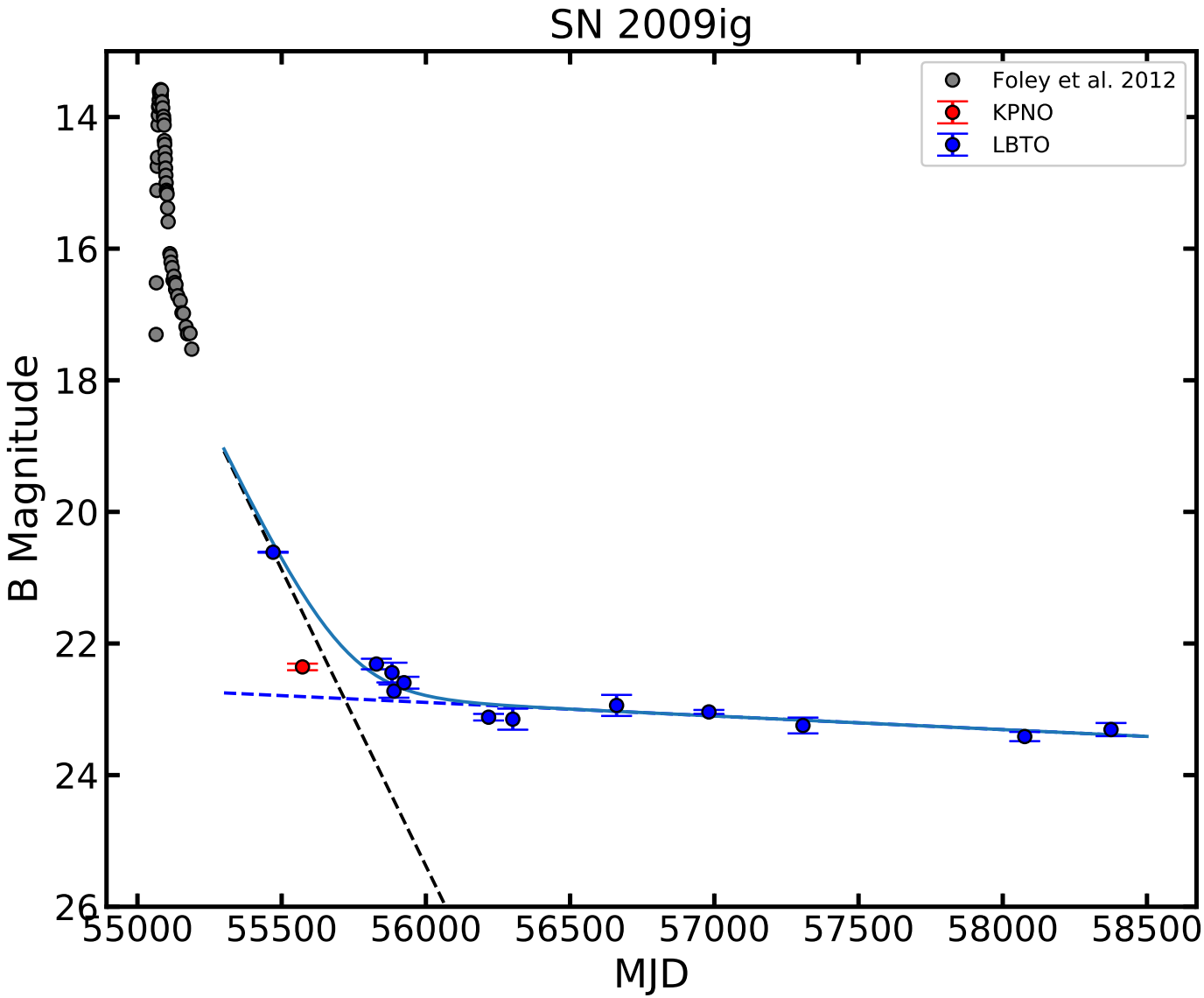
- Obtain spectra of SN2009ig?
  - May be too faint
  - Alternative: analyze R-band data (2010-2018), early V, I, J, H, & K_s data (2011)

Image credit - ESA/Hubble & NASA, A. Riess

Questions?


SN 2009ig
Foley et al. 2012
KPNO
LBTO
B Magnitude
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56500
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