Shaping: Follow the angular momentum!

Noam Soker

Department of Physics, Technion

Dictionary translation of my name from Hebrew to English (real!):

Pleasantness Review

Planetary Nebulae are on the cross-road of many astrophysical objects

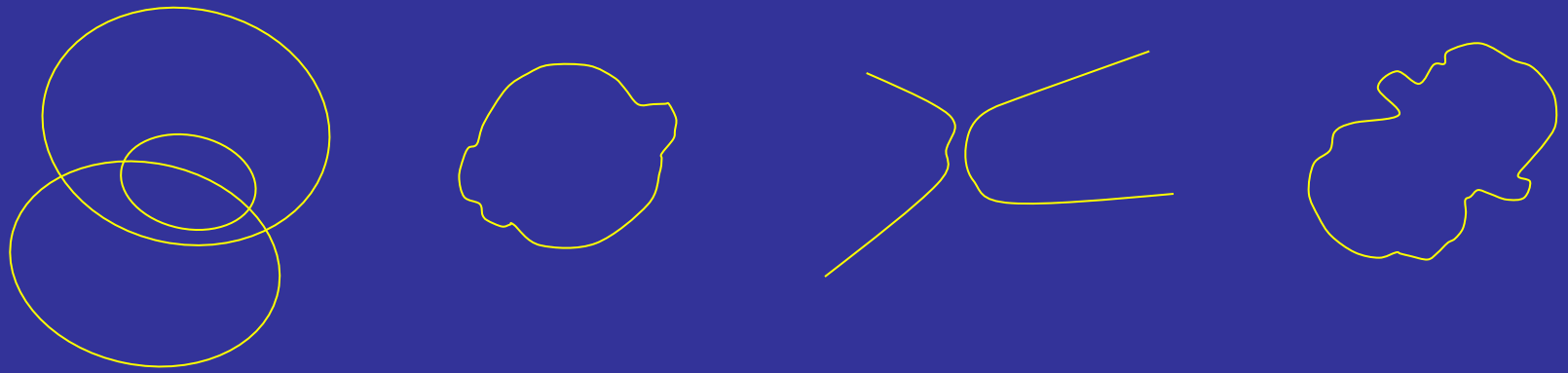
Typical shapes of some PNe

MyCn 18

IC 418

NGC 6302

Hb 5



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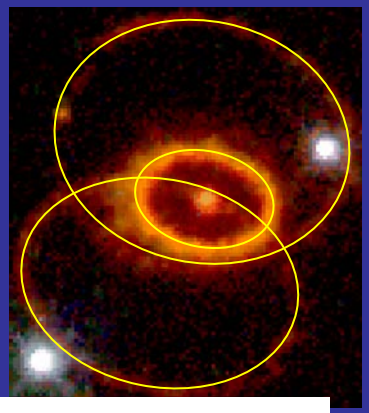
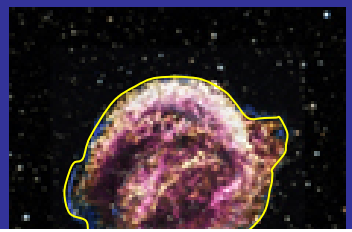
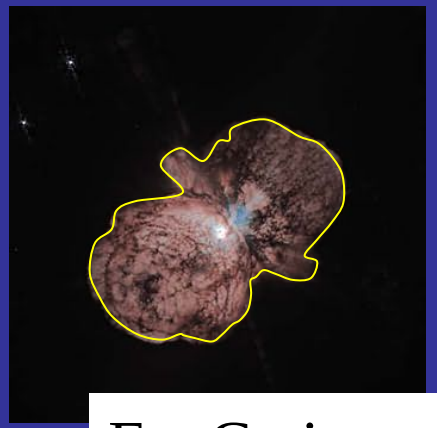


SN 1987A



Kepler SN remnant (Type Ia)

Young star S106 IR in star forming region



Eta Carinae

G299-2.9 SN remnant

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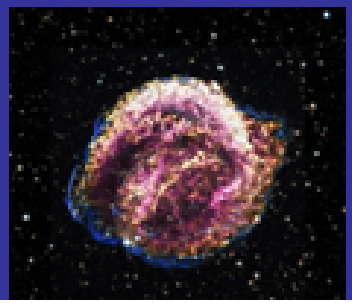

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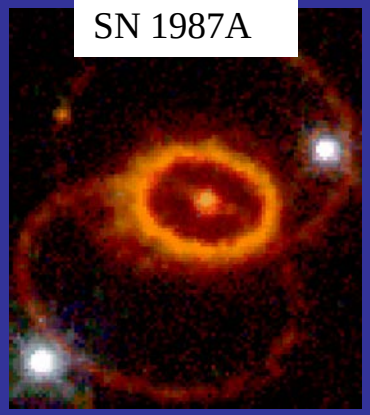
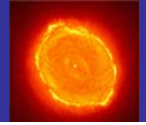


Popular models involve merger of a main sequence companion with the red supergiant progenitor. Rings formed before death.



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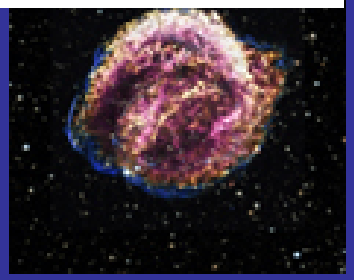

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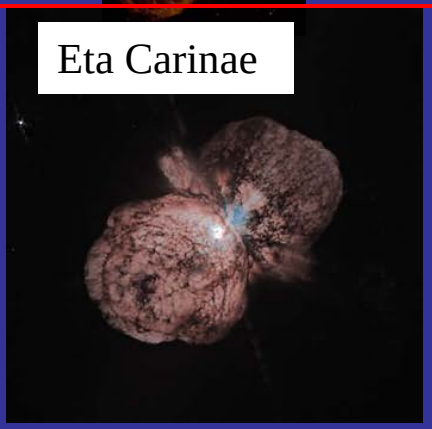

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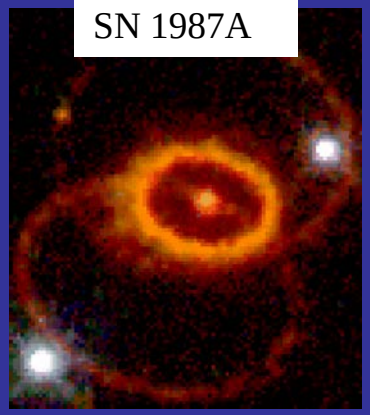

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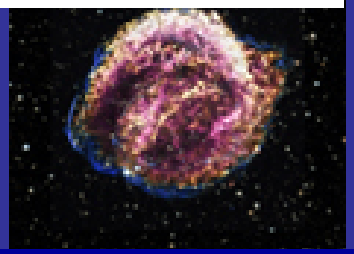

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➔ Jets

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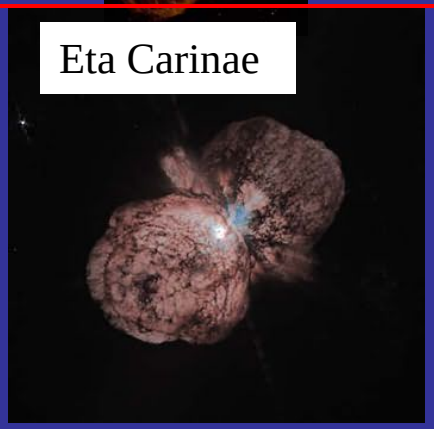

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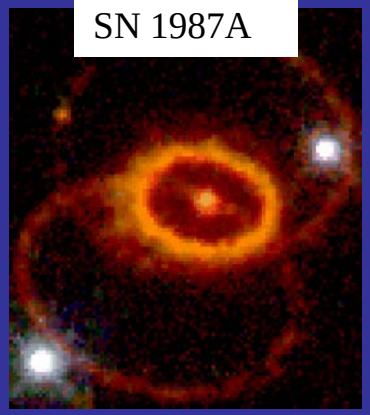

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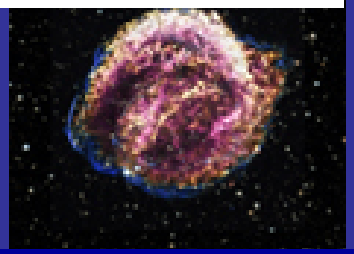

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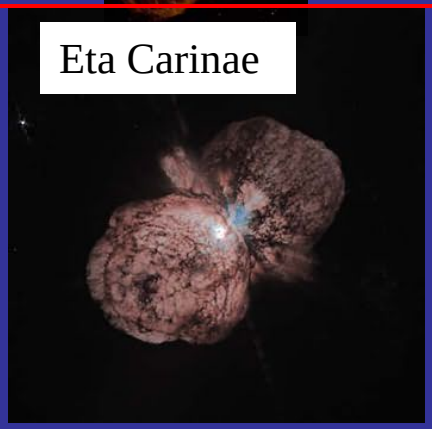

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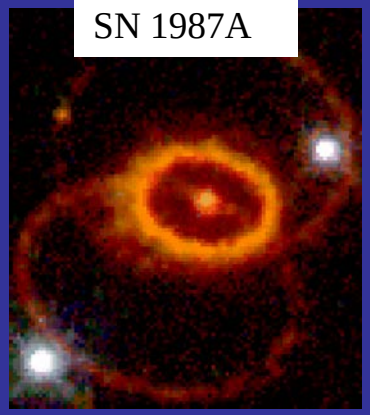

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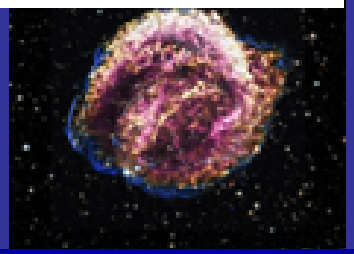

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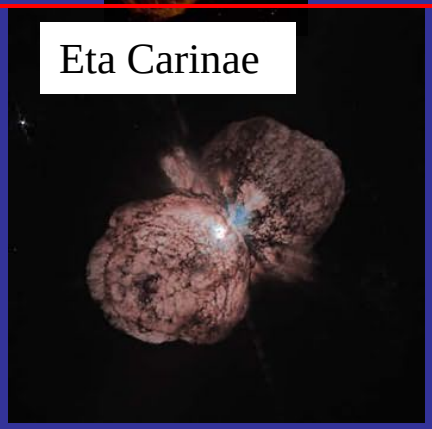
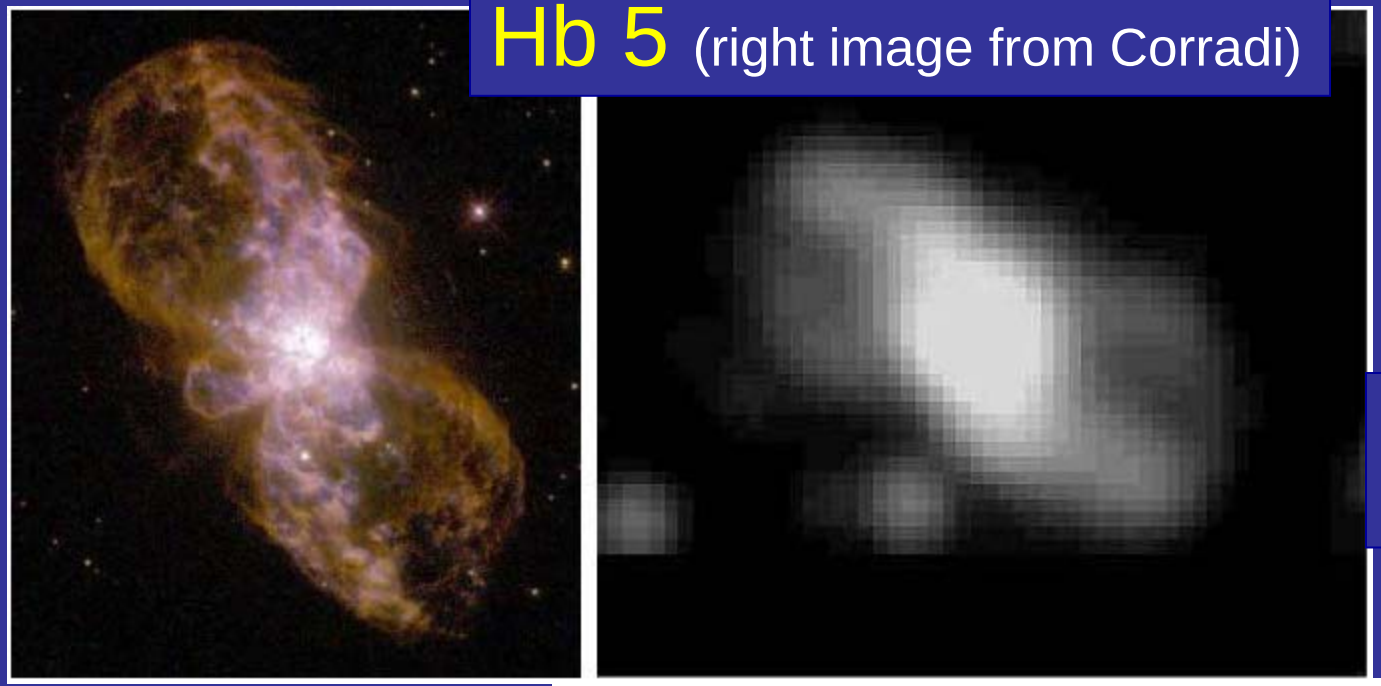


Bipolar nebula (Homunculus) was formed in 3-4 short outbursts during periastron passages ➔ impulsive jets

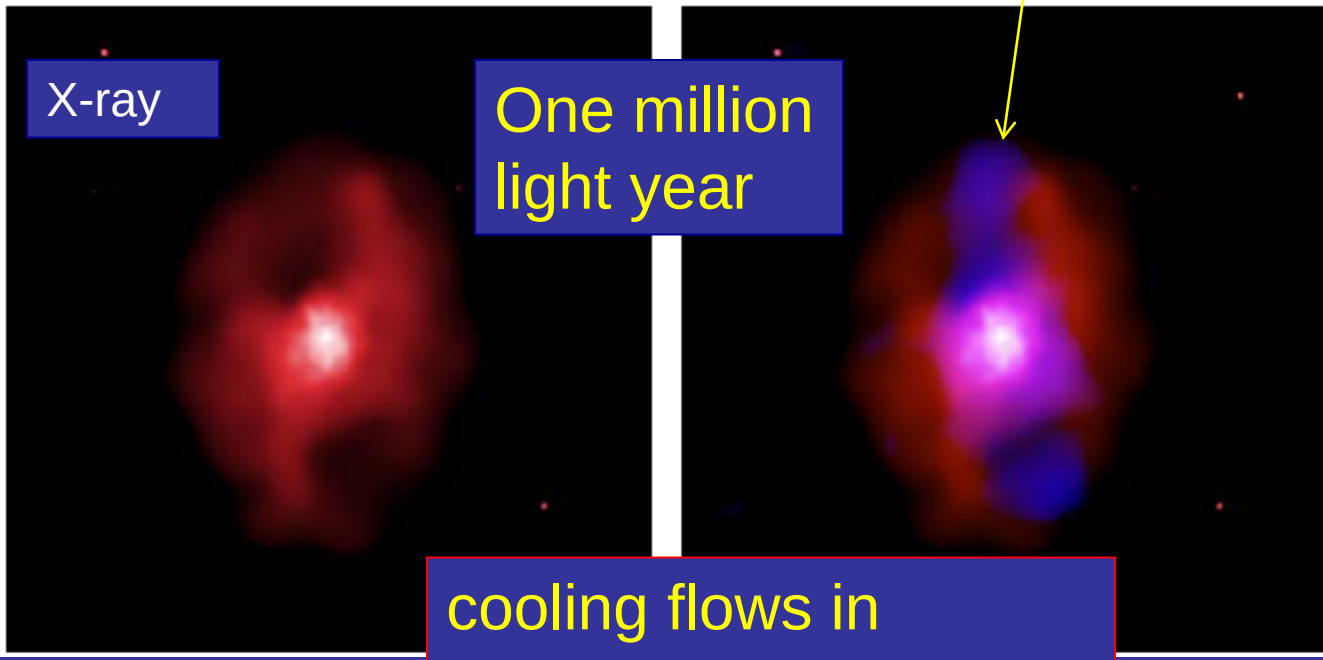
Binary period: 5.5 years; e ~ 0.9

Hb 5 (right image from Corradi)



Radio ➔ shaping by jets

- No common envelope.
- No equatorial mass loss.
- No large dipole B-field SN Ia
- No binary mass transfer.



cooling flows in clusters of galaxies.

Hb 5 (right image from Corradi)

JETS

Radio ➔
shaping by jets

- No comm
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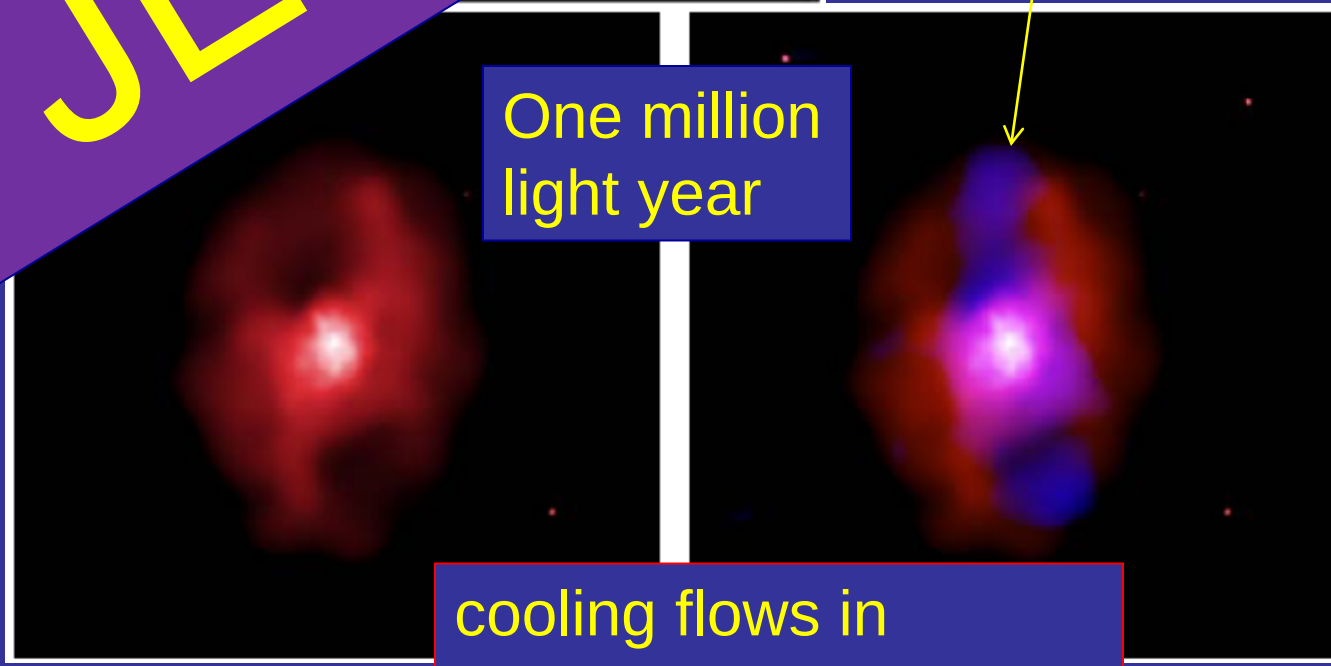
- N
  ma
- No la e
  B-fiel N Ia
- No binary mass transfer.

One million light year



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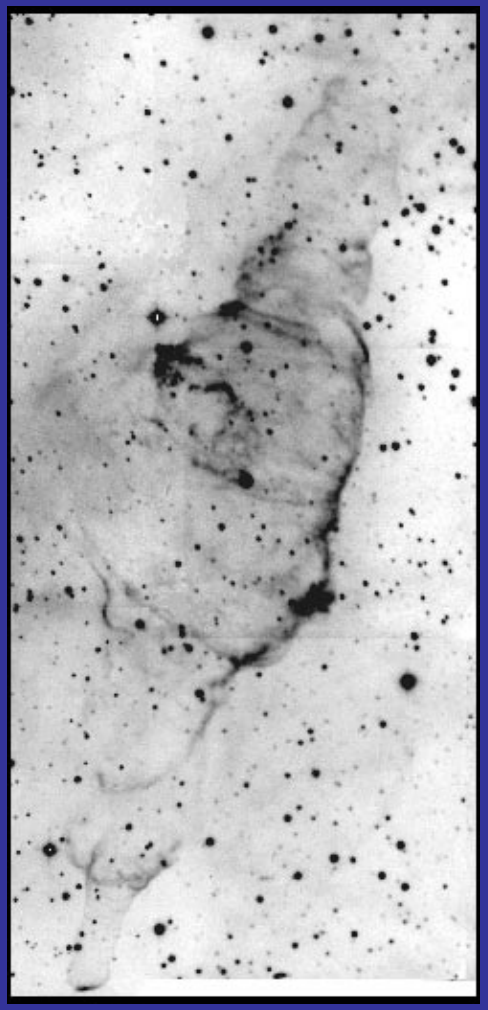
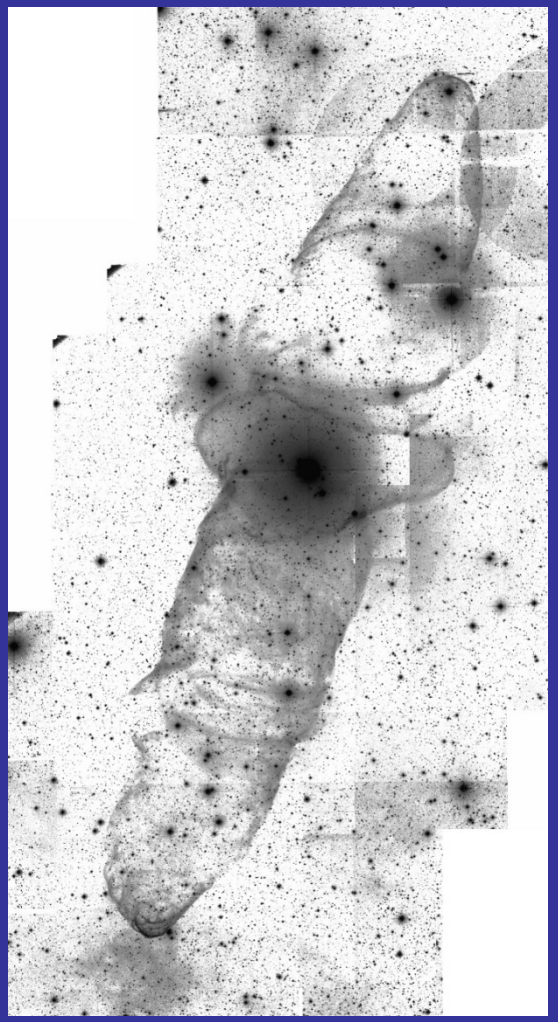


KjPn8
(Lopez et al. 2000)



Ou4: Young stellar object
(See Poster)

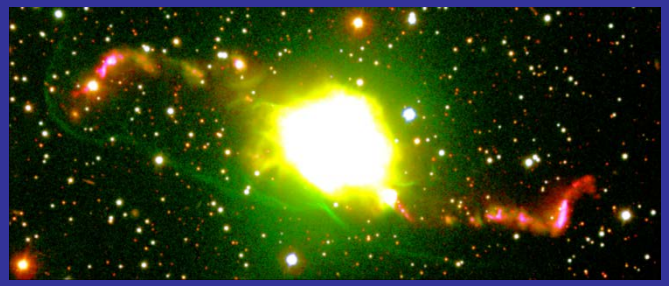
My view: All bipolar nebulae (PNe; Symbiotic nebulae; Eta Carinae; YSO lobes; bubbles in clusters of galaxies and in galaxies) are shaped by **Jets that are launched by an accretion disk around a compact object.**

My view: All bipolar nebulae (PNe; Symbiotic nebulae; Eta Carinae; YSO lobes; bubbles in clusters of galaxies and in galaxies) are shaped by **Jets that are launched by an accretion disk around a compact object.**

In channeling accretion energy to shaping/heating/ejecting the ambient gas, jets are much more efficient than radiation.

- **Jets and binarity (mass transfer)**

Fleming 1
1.2 days poriod
(Boffin et al.)



Jets can be formed before the nebular disk, hence are **not** collimated by the nebular disk. They are formed by an **accretion disk** around one of the stars (most likely around the companion).

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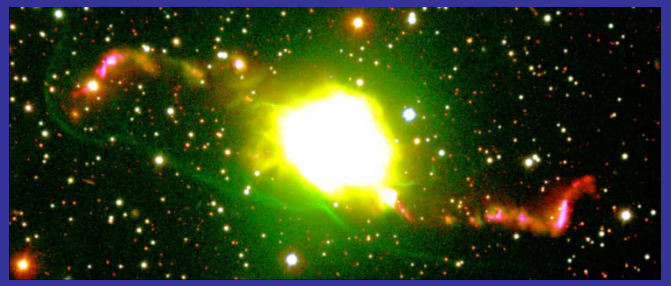


Jets can be formed before the nebular disk, hence are **not** collimated by the nebular disk. They are formed by **accretion disk** around one of the stars (most likely around the companion).

Shaping by interacting winds exists, but cannot explain most morphologies (e.g. precession), and in any case requires some asymmetrical mass loss mechanism.

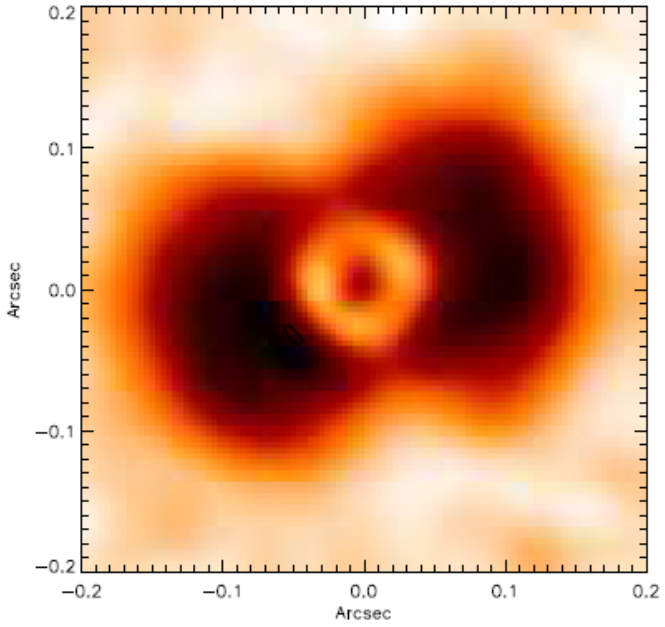


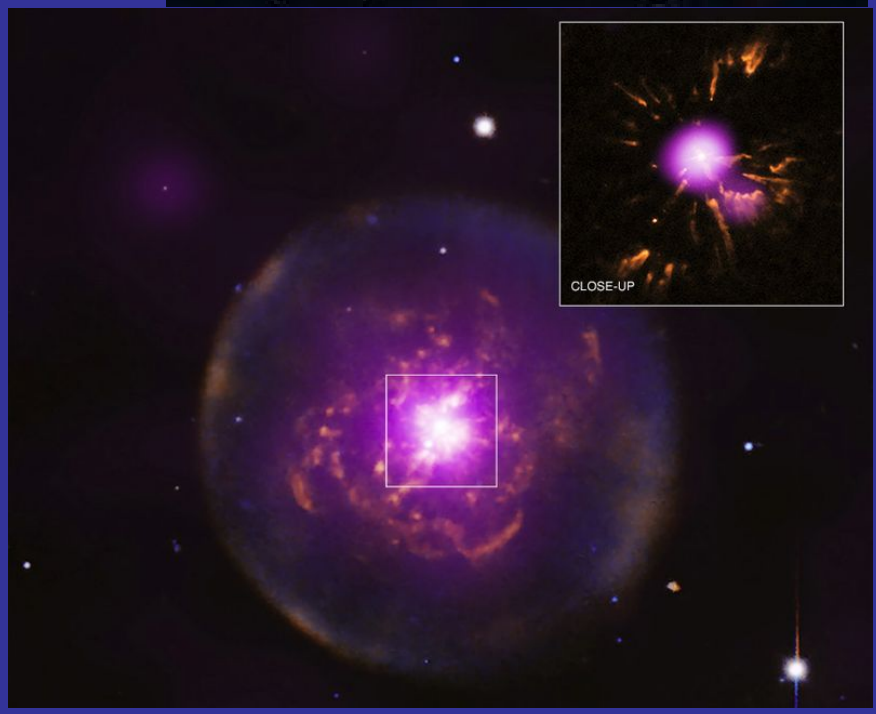
Fig. 4. 2010 NACO K band image after a PSF subtraction. The color table is inverted.

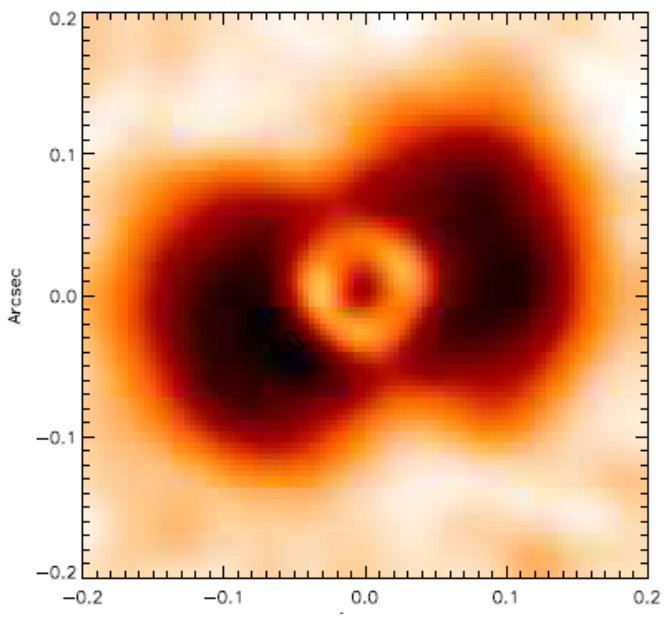
nova V1280 Sco

O. Chesneau, Eric Lagadec et al. (2012)

A30: Optical and X-ray (purple; Martin Guerrero).

NGC 2440





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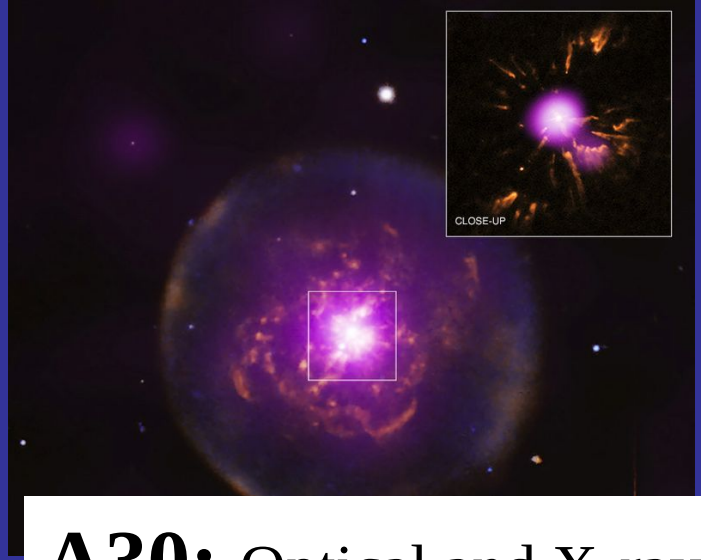

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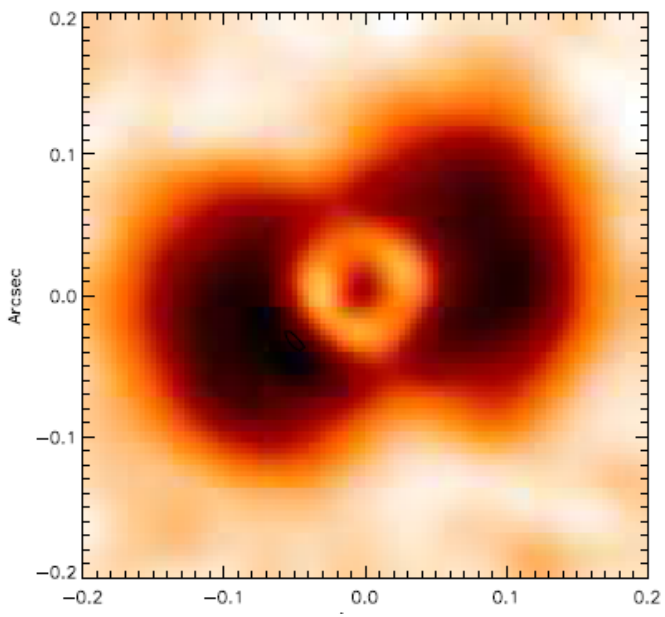
My view: Inner part of A30 formed by outburst triggered by fall back accretion onto the central star.



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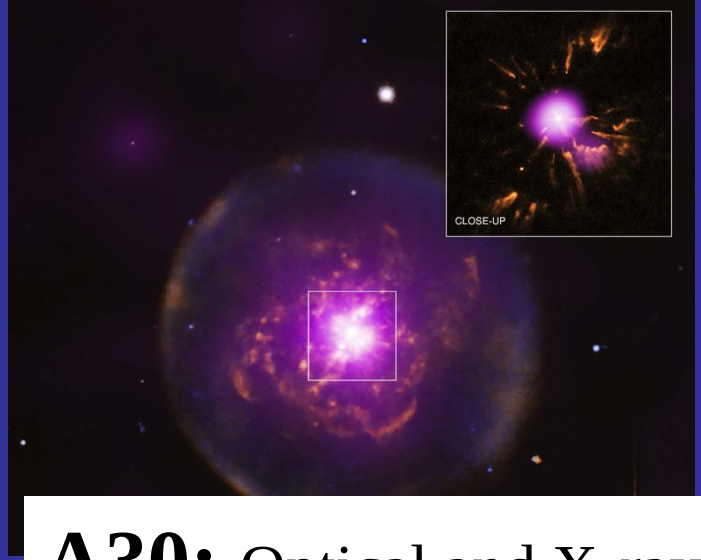

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This is strongly supported

by my wife and three kids

Main points:

Accretion into a compact object gives:

(1) Gravitational energy from a small amount of accreted gas.

(2) Jets that

(a) are efficient in channeling energy to the ambient gas, and

(b) form bipolar structures of different kinds.

In addition there are the effect of binary motion (mentioned yesterday):

- **Spiral structure Equatorial mass ejection**
- **Departure from axi-symmetry (look for it!)**
- **Spiral structure**
- **Eruption of the central star.**

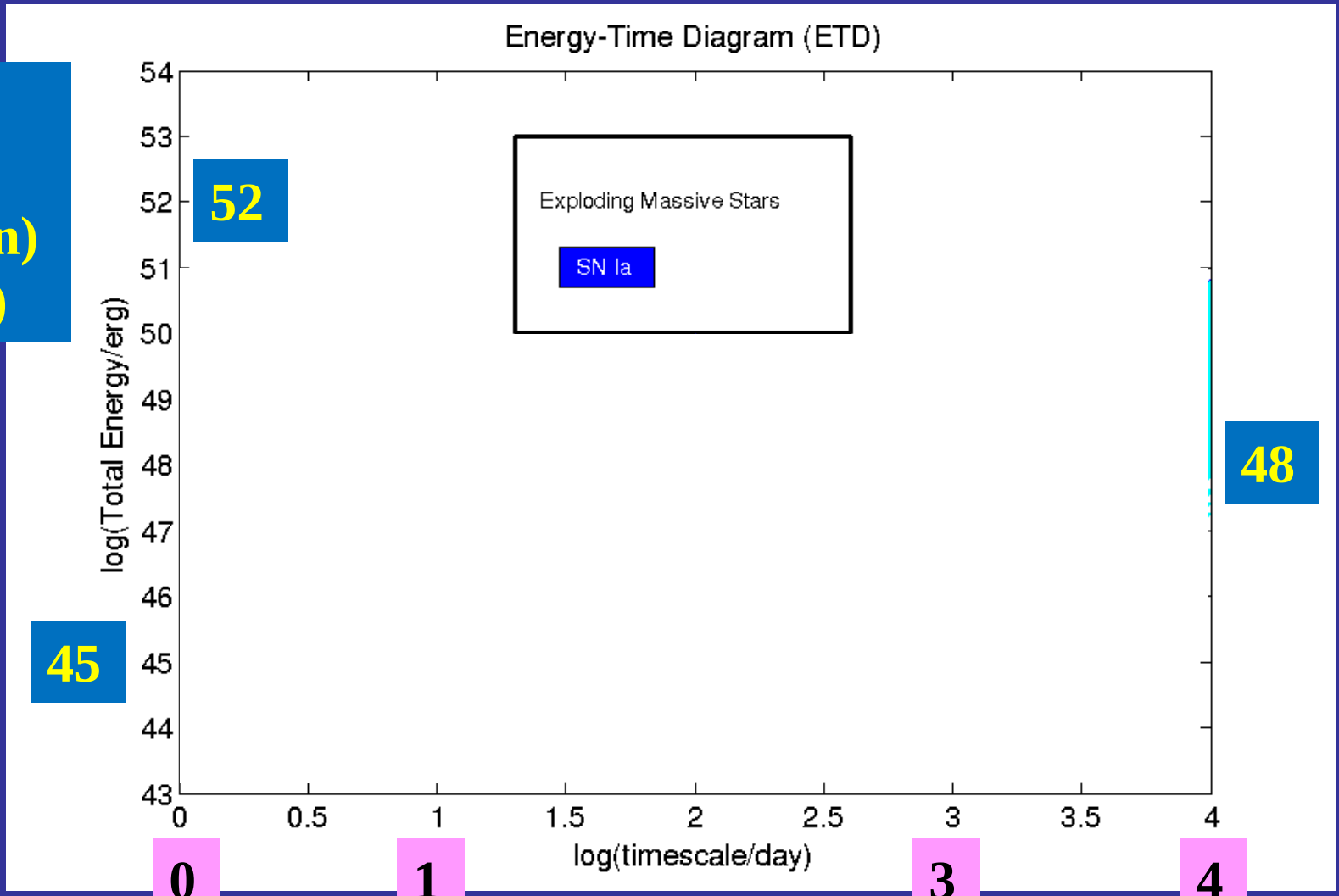
More on jets:

Jets are likely to be launched by the accretion disk when the accretion rate is very high.

This requires a high mass transfer rate.

Let us examine such systems.

Total (Kinetic +radiation) log(E/erg)



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Log(time/day)

From *Amit Kashi*
Updated in:
http://physics.technion.ac.il/~ILOT/

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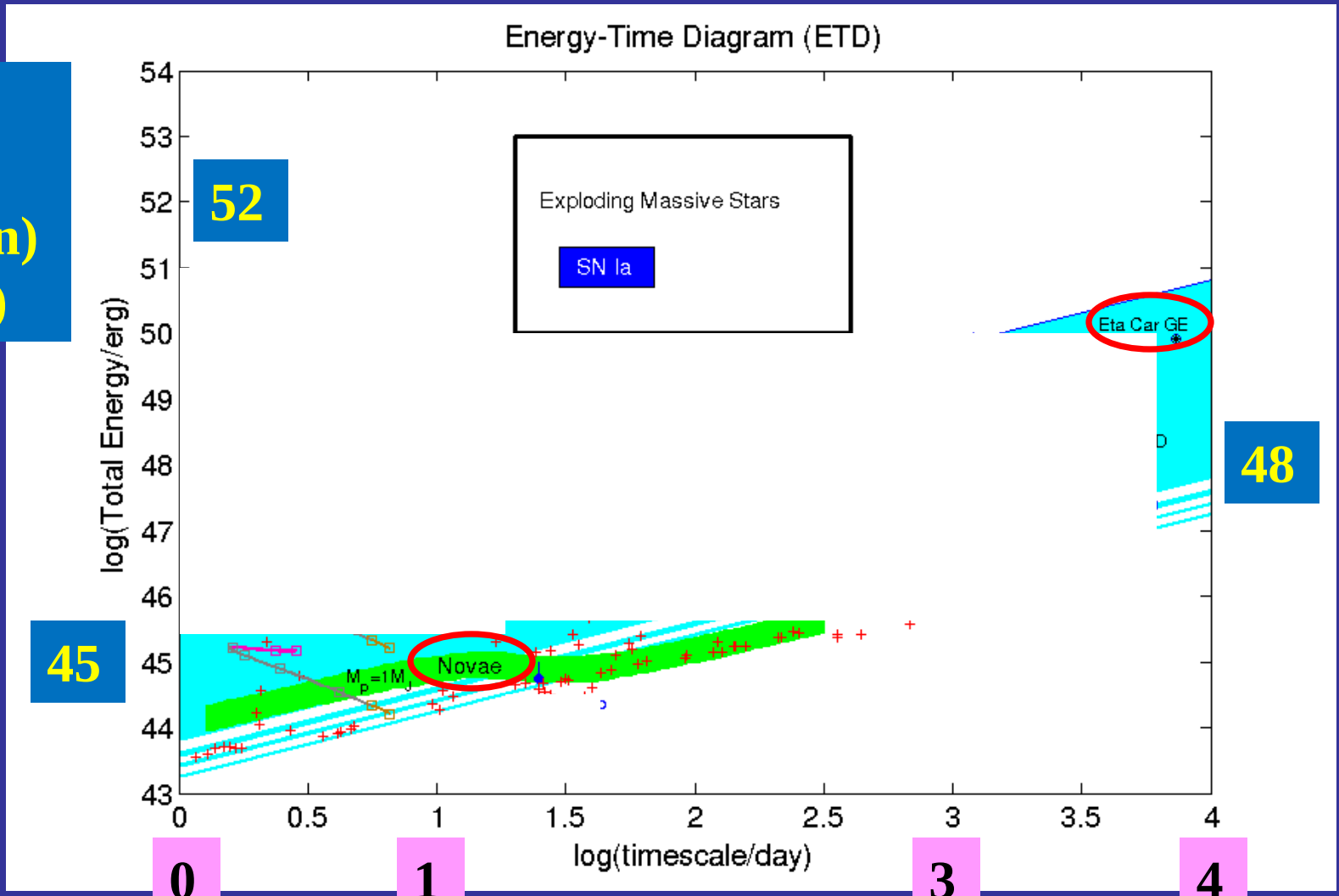

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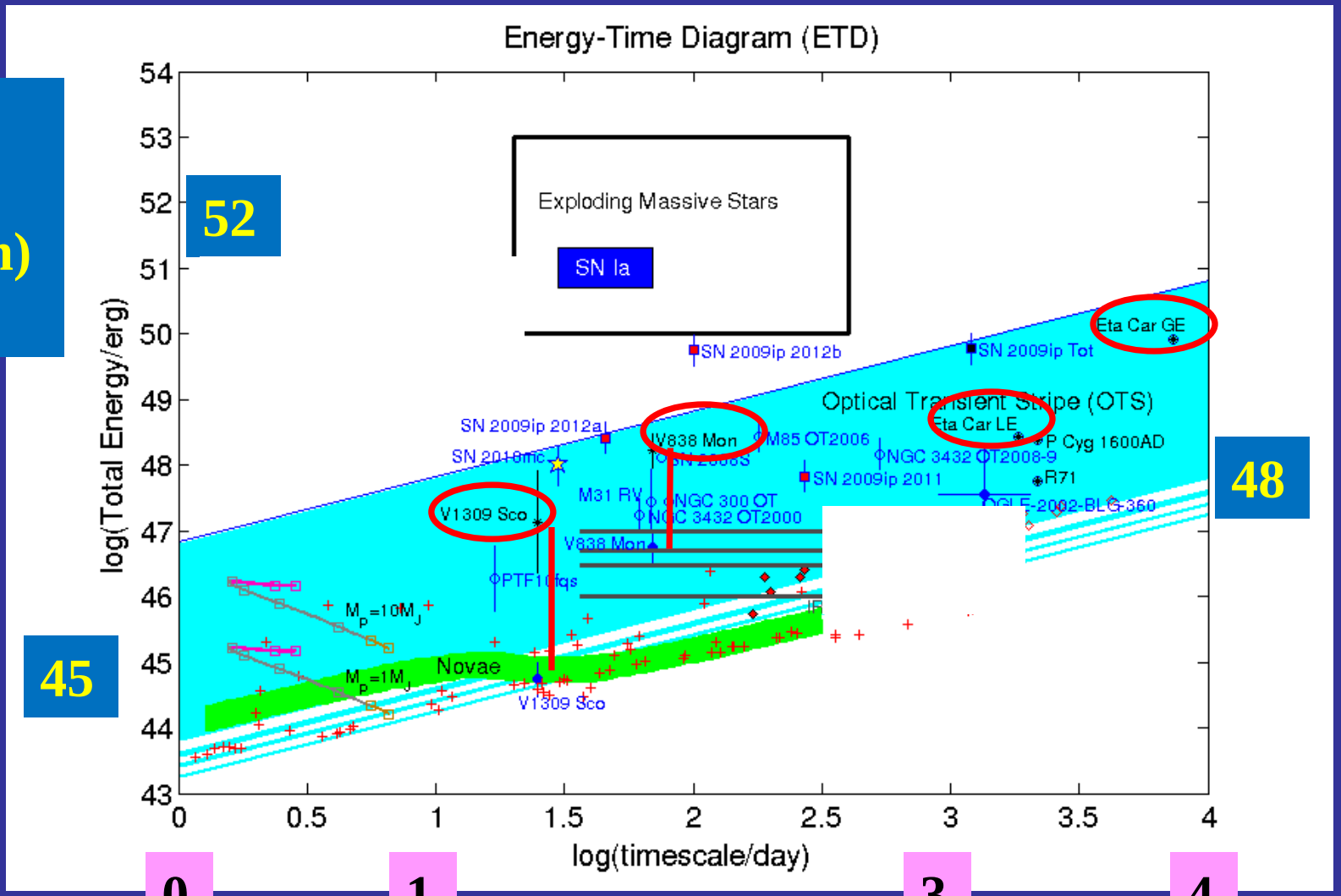

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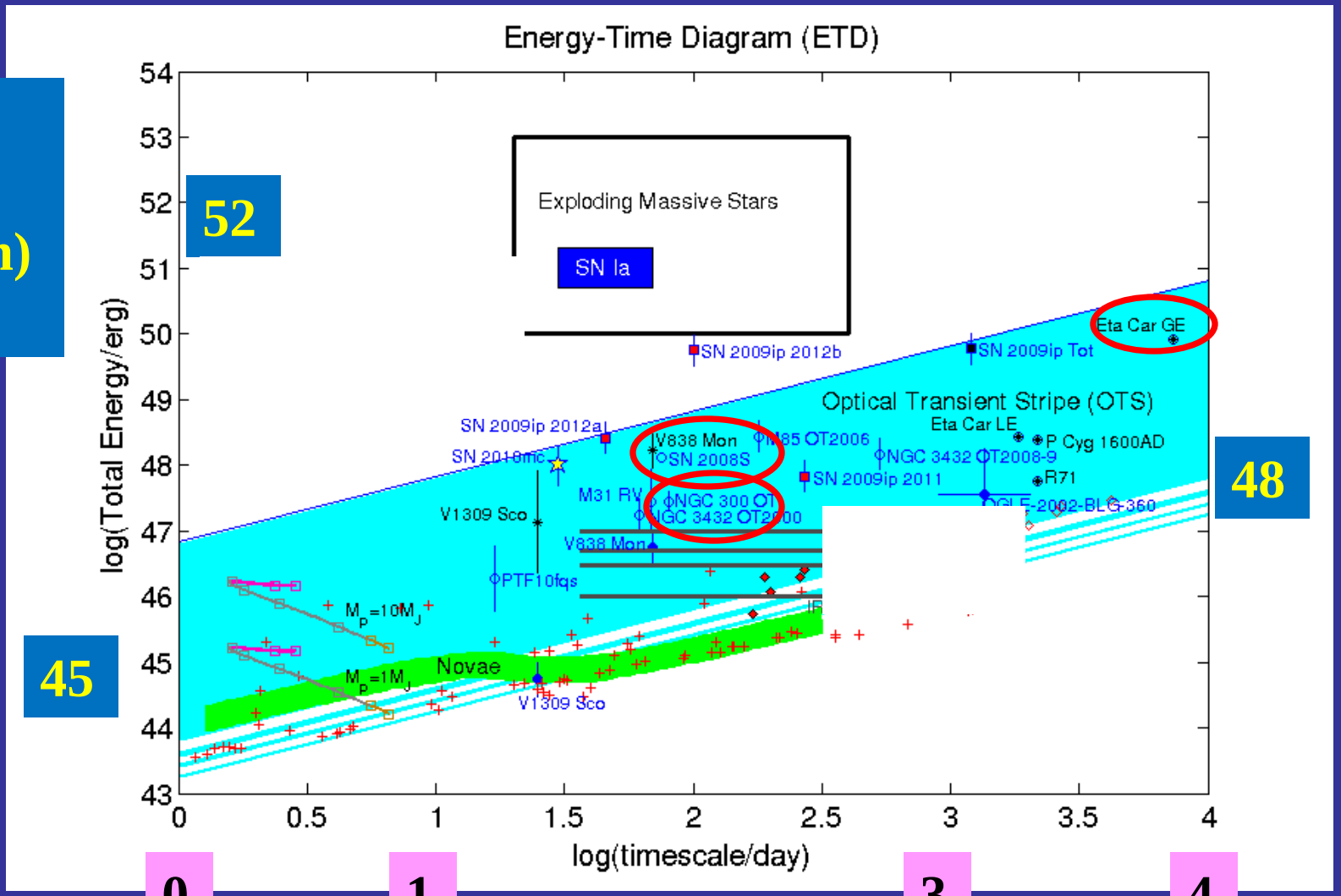

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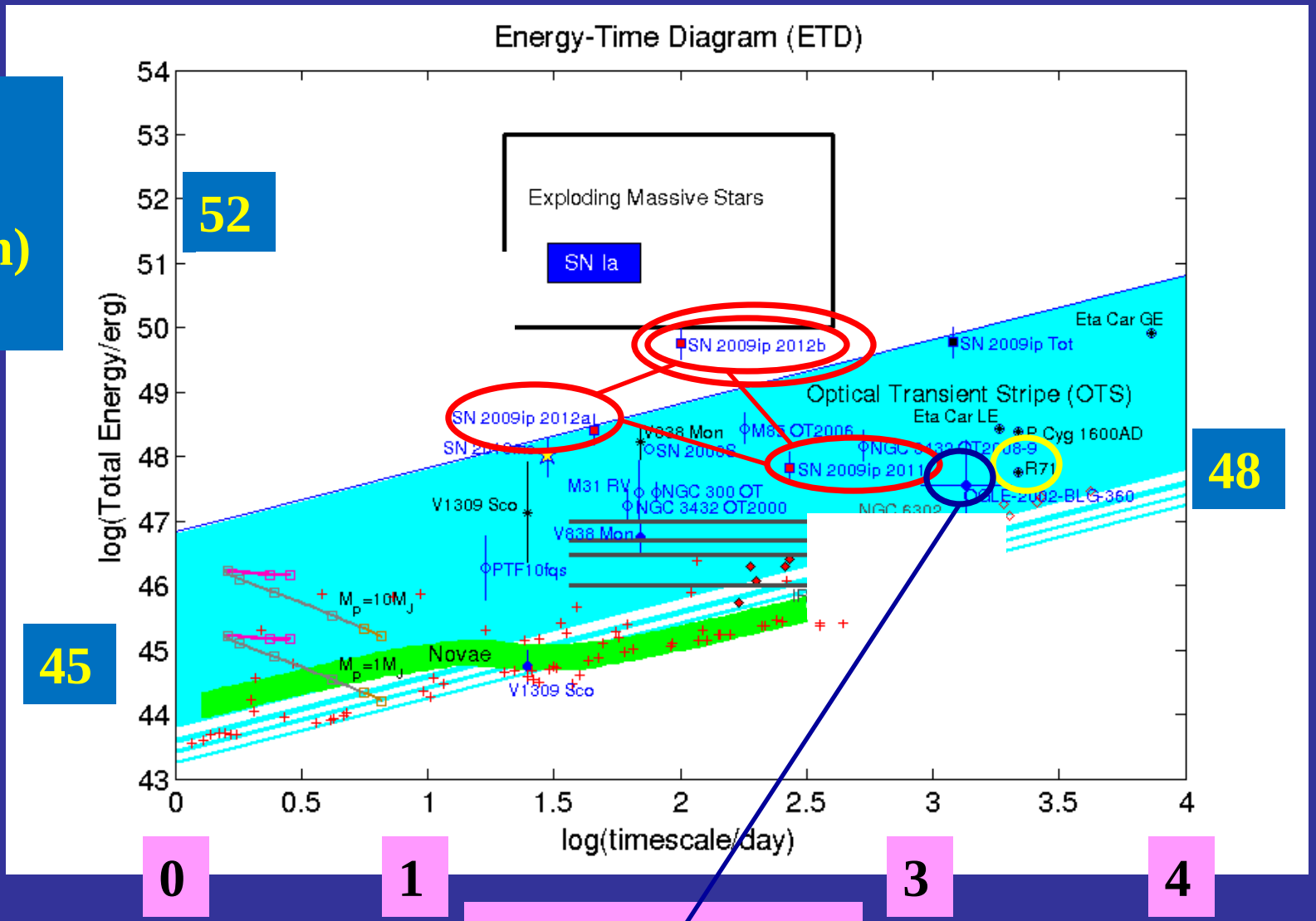

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OGLE-2002-BLG-360

Tylenda et al. (2013)

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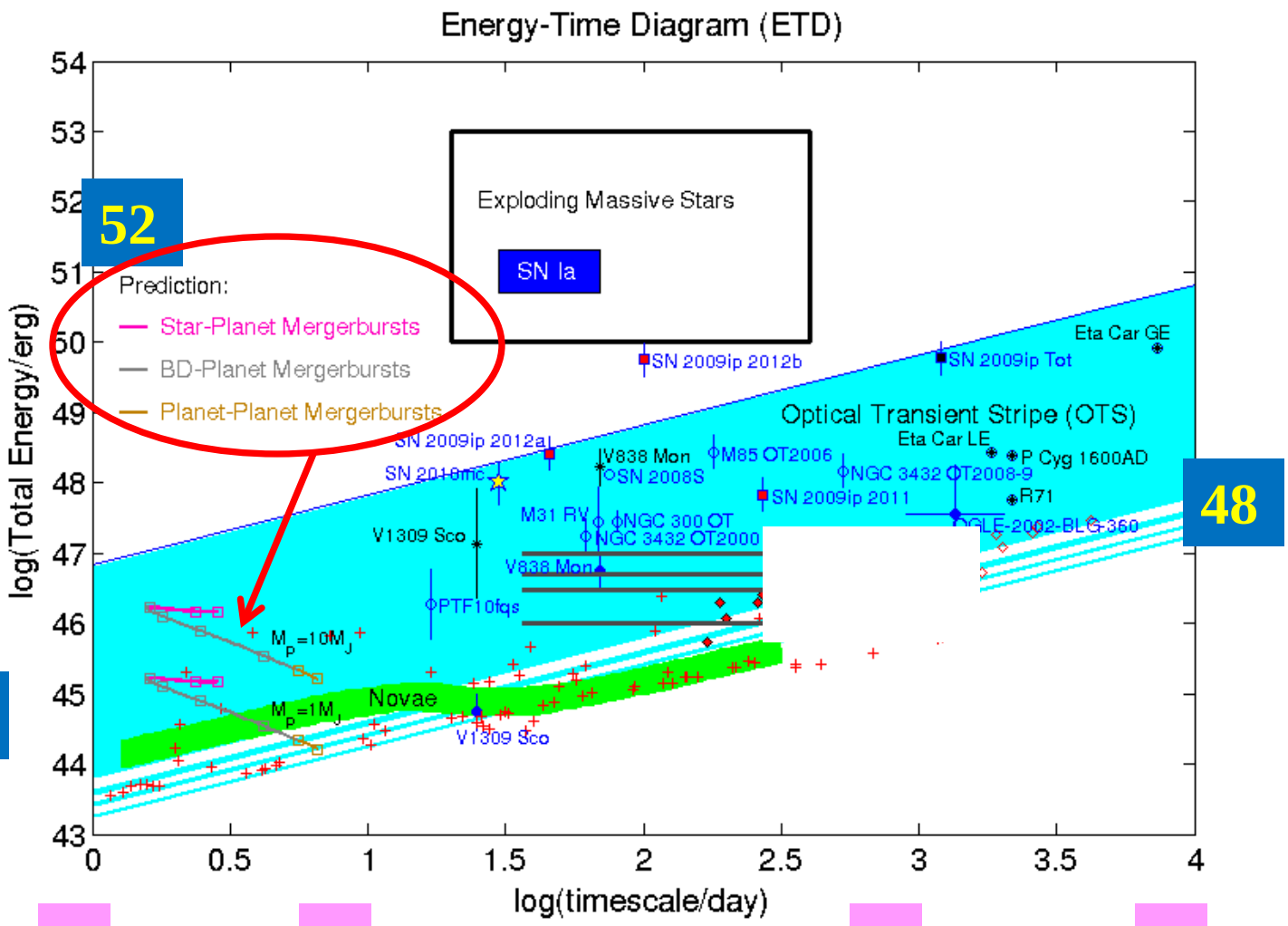

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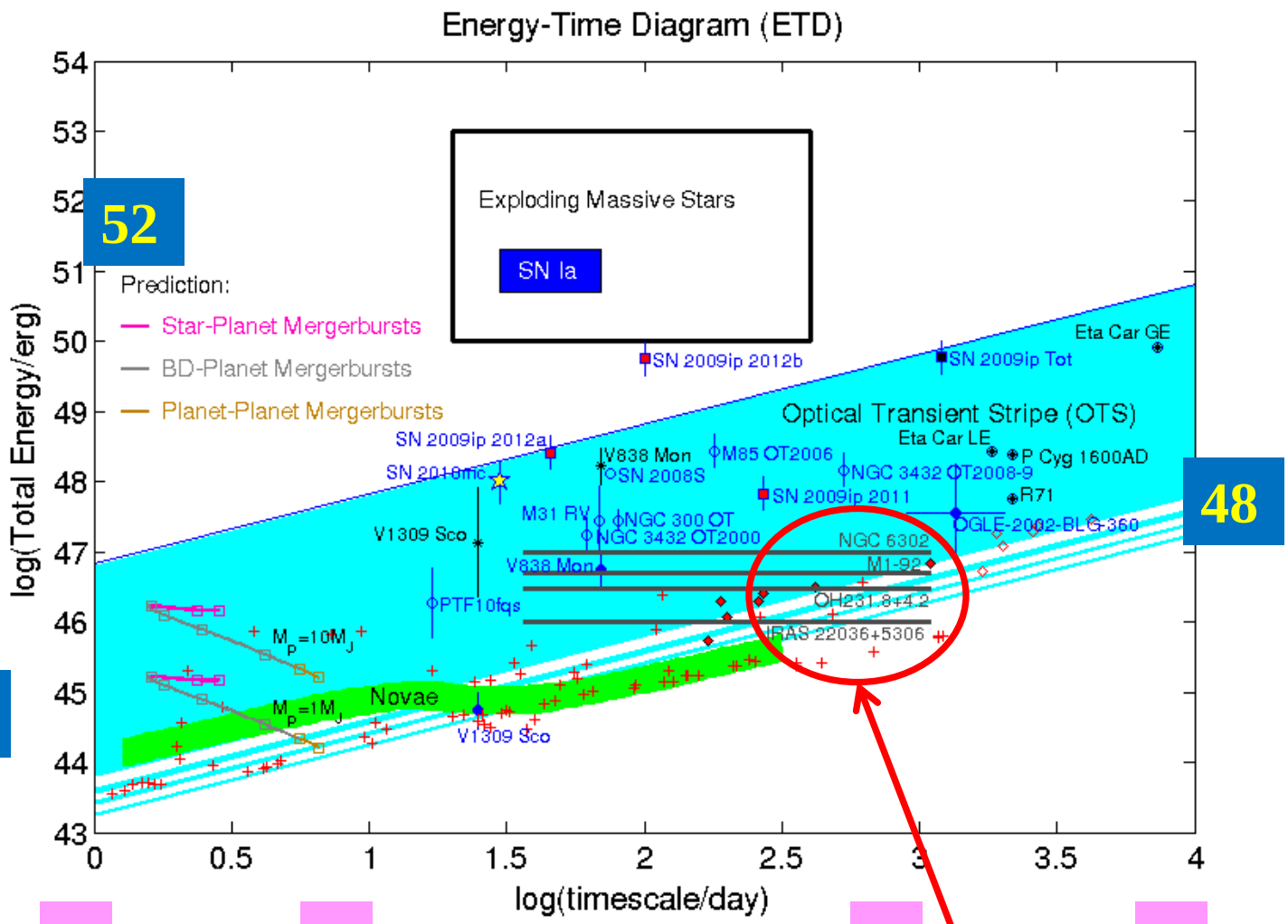

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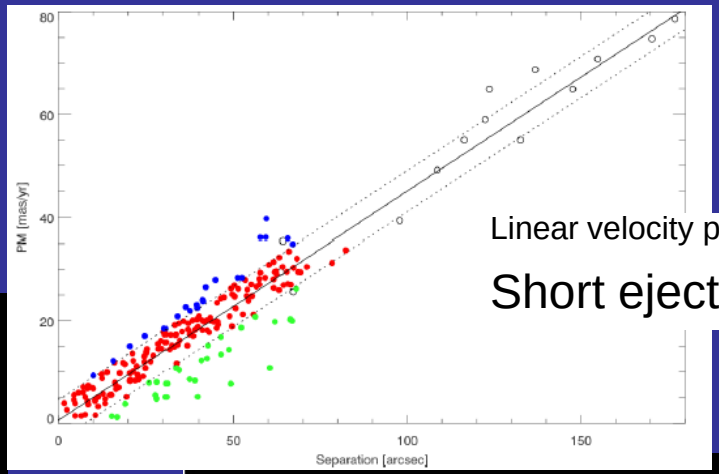
Suggestion (Kashi & Soker) : Planetary nebulae and pre-PNe.
Talk by Muhammad Akashi.

NGC 6302



Linear velocity position relation:

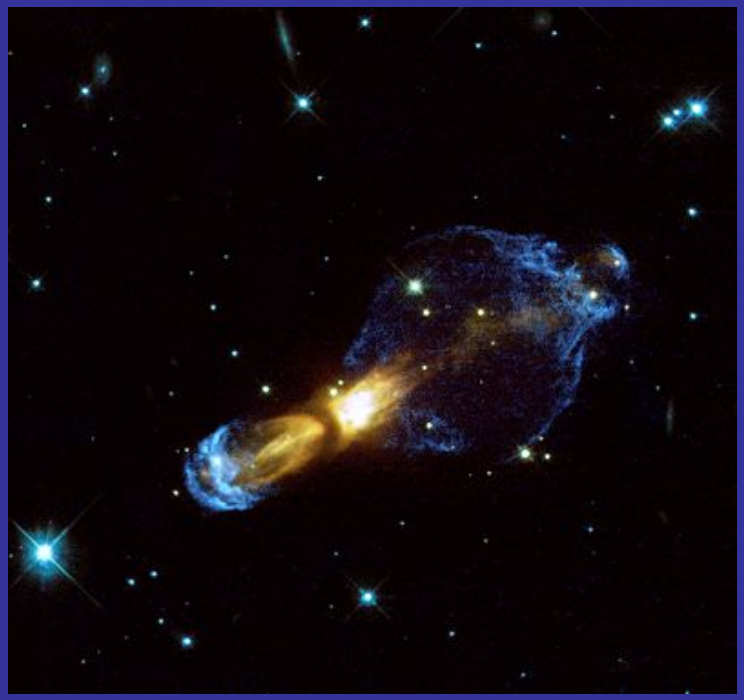
Short ejection episode.

NGC 6302 G349.5+01.0 17 13 44.21 -37 06 15.9, R:G:B = Halpha
credit: Romano Corradi
ref: http://www.iac.es/gabinete/difus/ruta/romano/imagen/n6302ha.gif

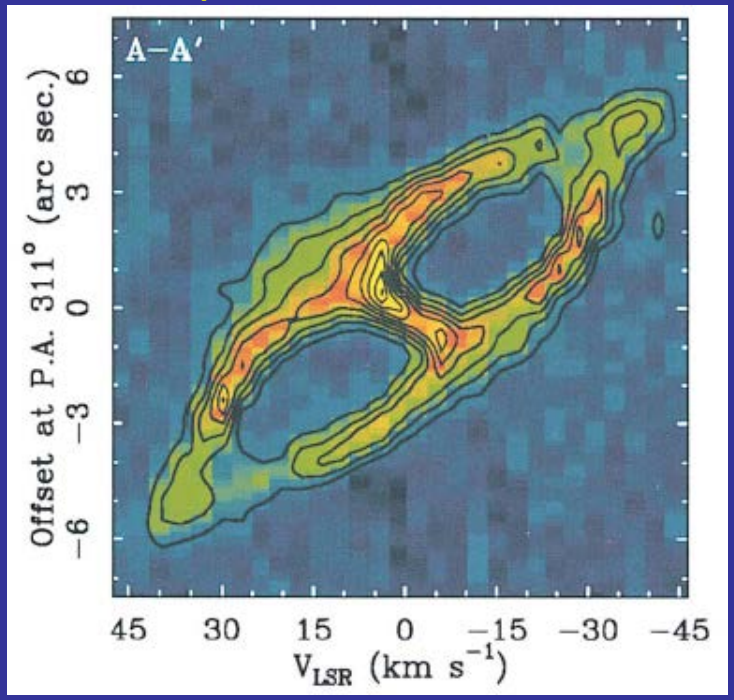
Romano Corradi

Szyszka, C.; Zijlstra, A. A.; Walsh, J

Pre-Pne that formed in a short time: ILOTs (Red Novae)?



OH231.8+4.2
(Bujarrabal et al. 1998)



M1-92 (Bujarrabal et al. 1998)

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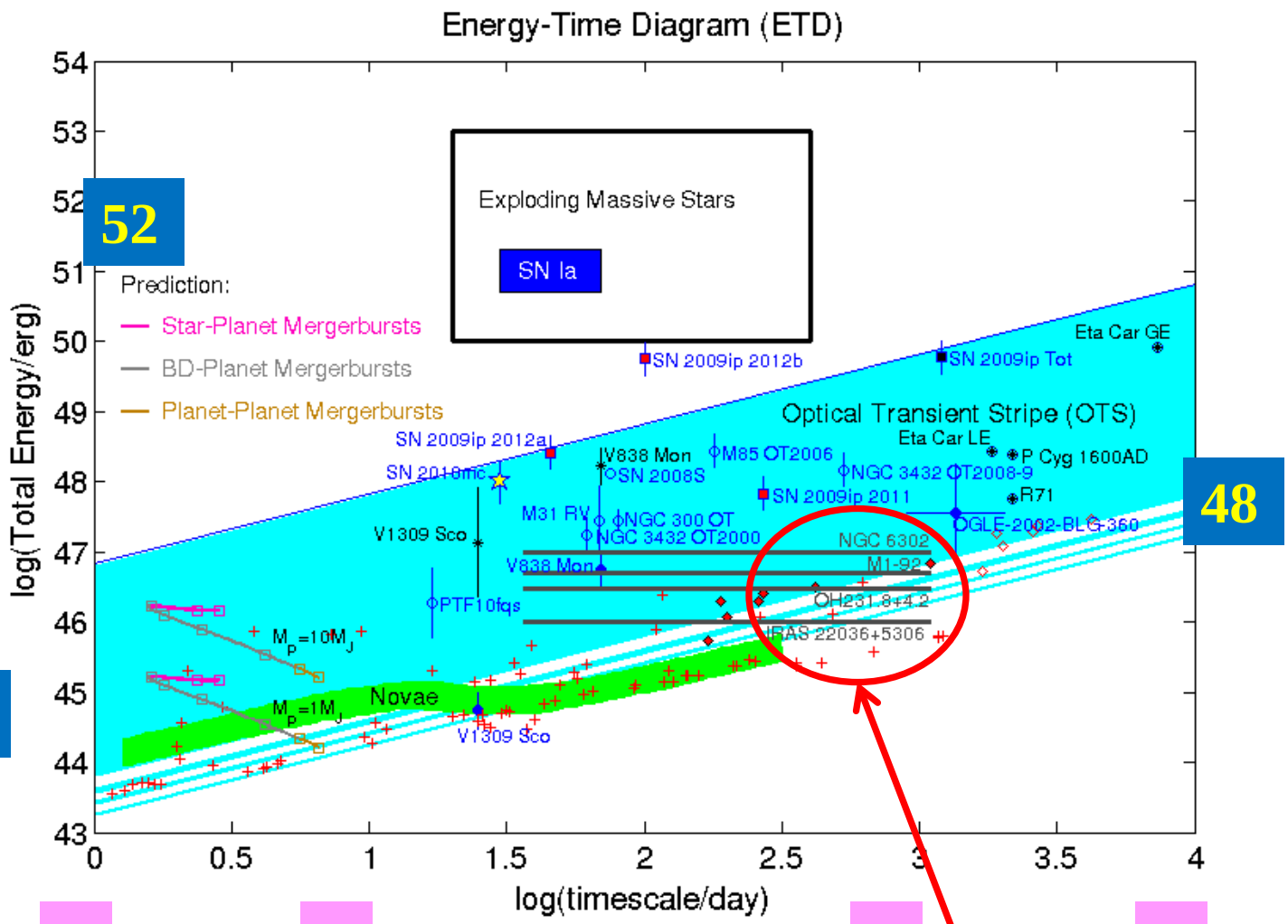

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