Pleasantness Review*

Department of Physics, Technion, Israel

The core degenerate scenario of type Ia supernovae and interacting type Ia supernovae

Stockholm 2018

Noam Soker

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

Noam = Pleasantness

Soker = Review

A short summary

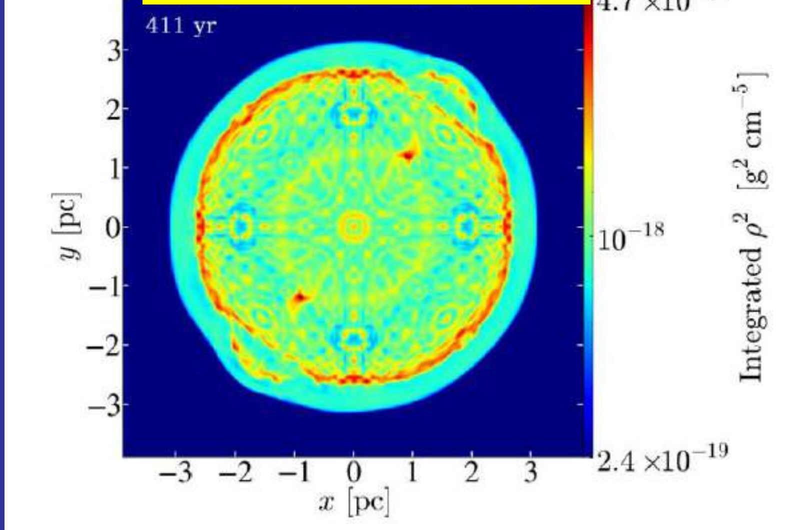
JETS

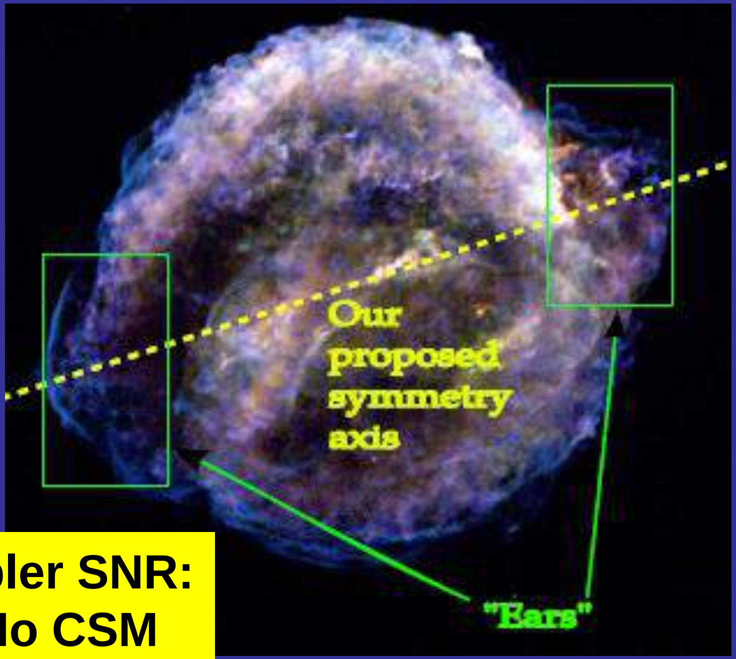
See review Soker, N., 2016, New Astronomy Review 75, 1
(arXiv:160502672):

“The jet feedback mechanism (JFM) in stars, galaxies and clusters (a review)”

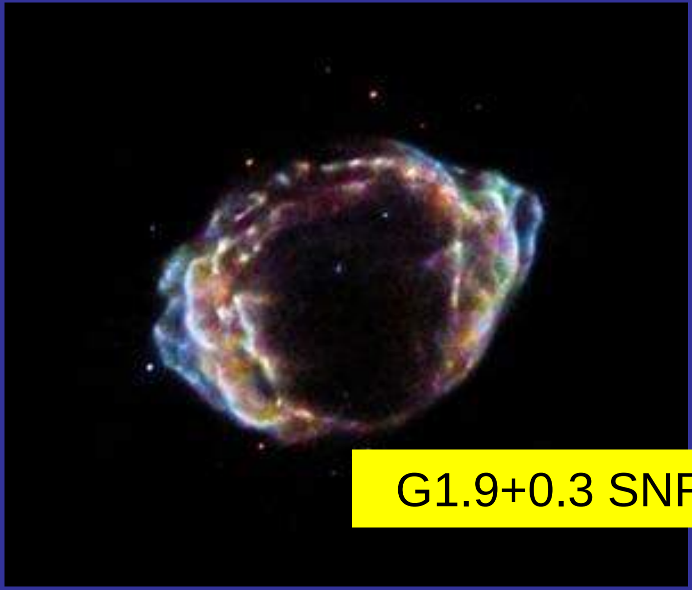
Ears in Type Ia SNRs

Jets' simulation

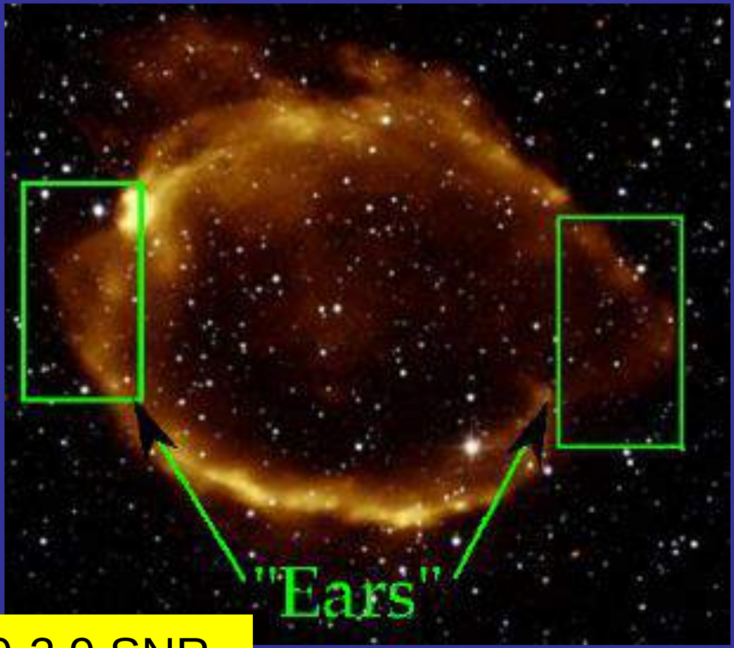




Kepler SNR:
~1Mo CSM



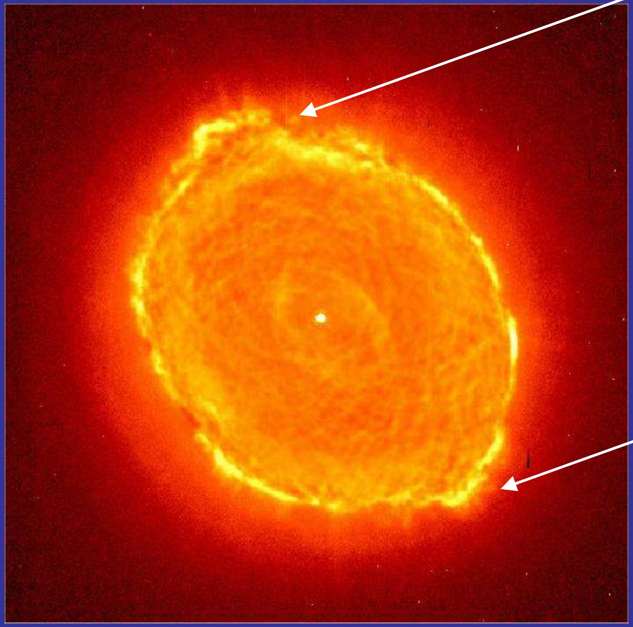
G1.9+0.3 SNR



G299-2.9 SNR

Ears in

A planetary nebulae

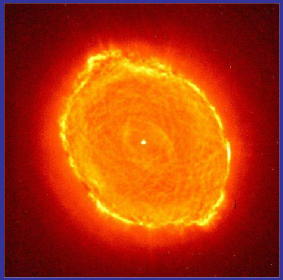


Ears

Ears in planetary nebulae

NGC 3242 G261.0+32.0 10 24 46.11 -18 38 32.6, R:G:B = log[NII]: log[OIII]: linear V
HST/WFPC2/PC1 N is NOT up. credit: Hajian et al (unpublished)
HST archives, GO 7501/8390/8773

IC 418 G215.2-24.2 05 27 28.20 -12 41 50.3, R:G:B = [NII], Ha, [OIII]
Hubble Heritage Team, HST/WFPC2/PC?, N is NOT up
ref: hubblesite.org/gallery/album/nebula_collection/pr2000028a/
inset: R:G:B = deep log[NII]:log [NII]:log[OIII] Hajian, HST archives GO7501

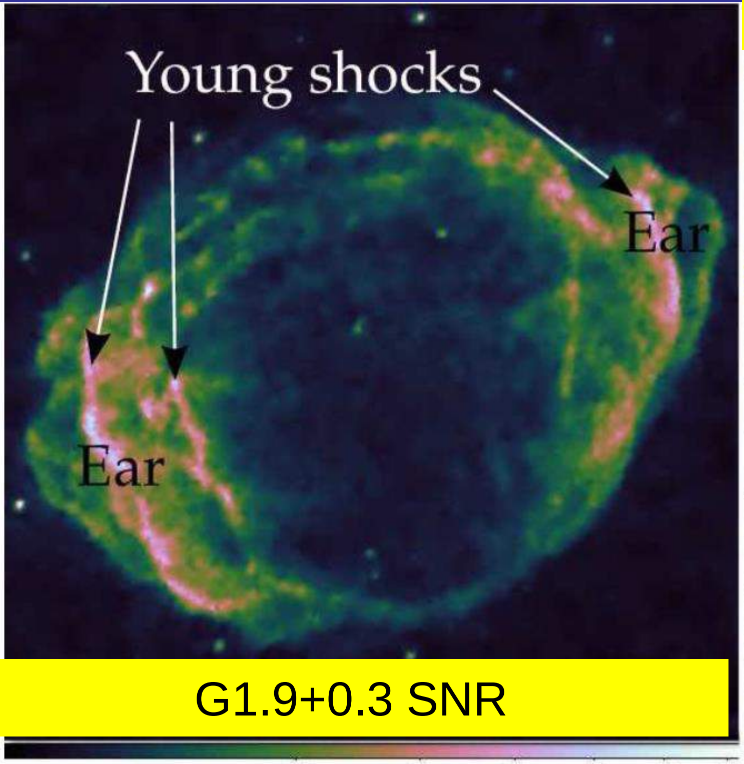


NGC 7139 G104.1+07.9 21 46 08.59 +63 47 29.4, R:G:B = unknown
credit: Gert Gottschalk and Sibylle Froehlich/Adam Block/NOAO/AURA/NSF
source: http://www.noao.edu/outreach/aop/observers/n7139.html

NGC 6563 G358.5-07.3 18 12 02.75 -33 52 07.1, R:G:B=log(Ha+[NII]),both,log[OIII]
ref: Schwarz, H.E., Corradi, R.L.M., Melnick, J 1992 A&A Suppl, 96, 23
image files courtesy R Corradi. N is NOT up. See ref for orientation.

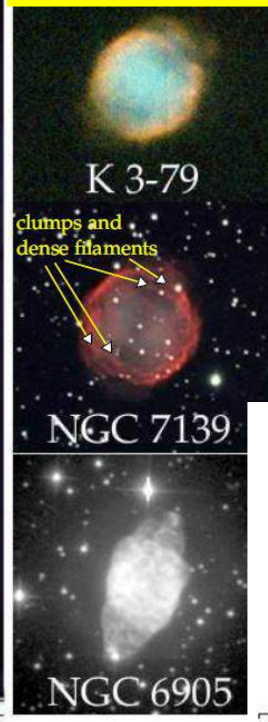
IC 2448 G285.7-14.9 09 07 06.26 -69 56 30.7, R:G:B = log[NII]: log[OIII]: linear V
HST/WFPC2/PC1 N is NOT up. credit: Hajian et al (unpublished)
HST archives, GO 7501/8390/8773

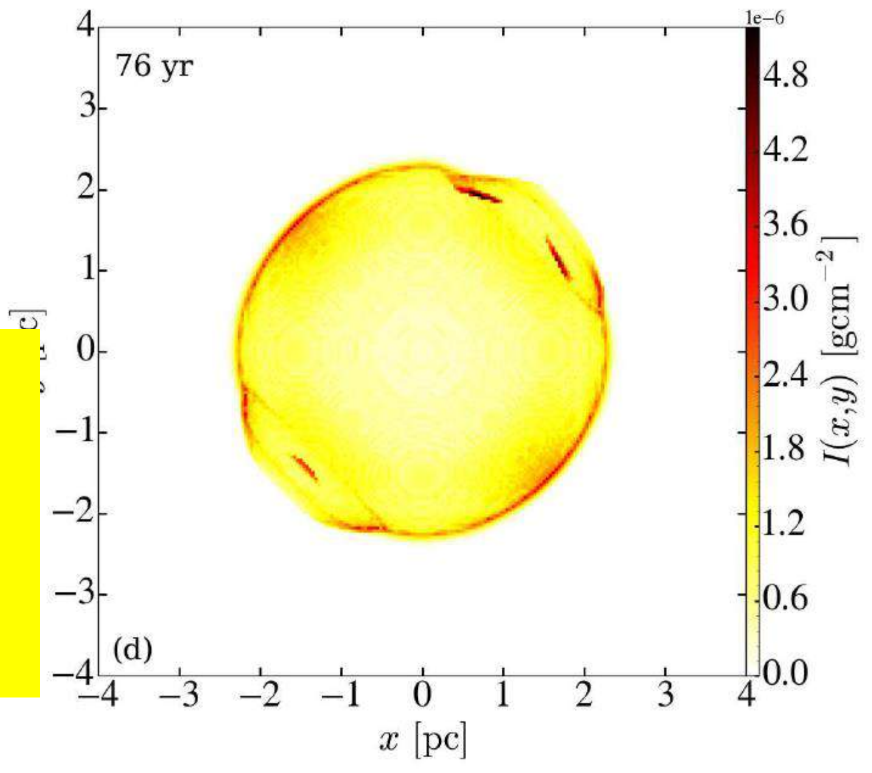
Ears in Type Ia SNRs



G1.9+0.3 SNR

Planetary nebulae



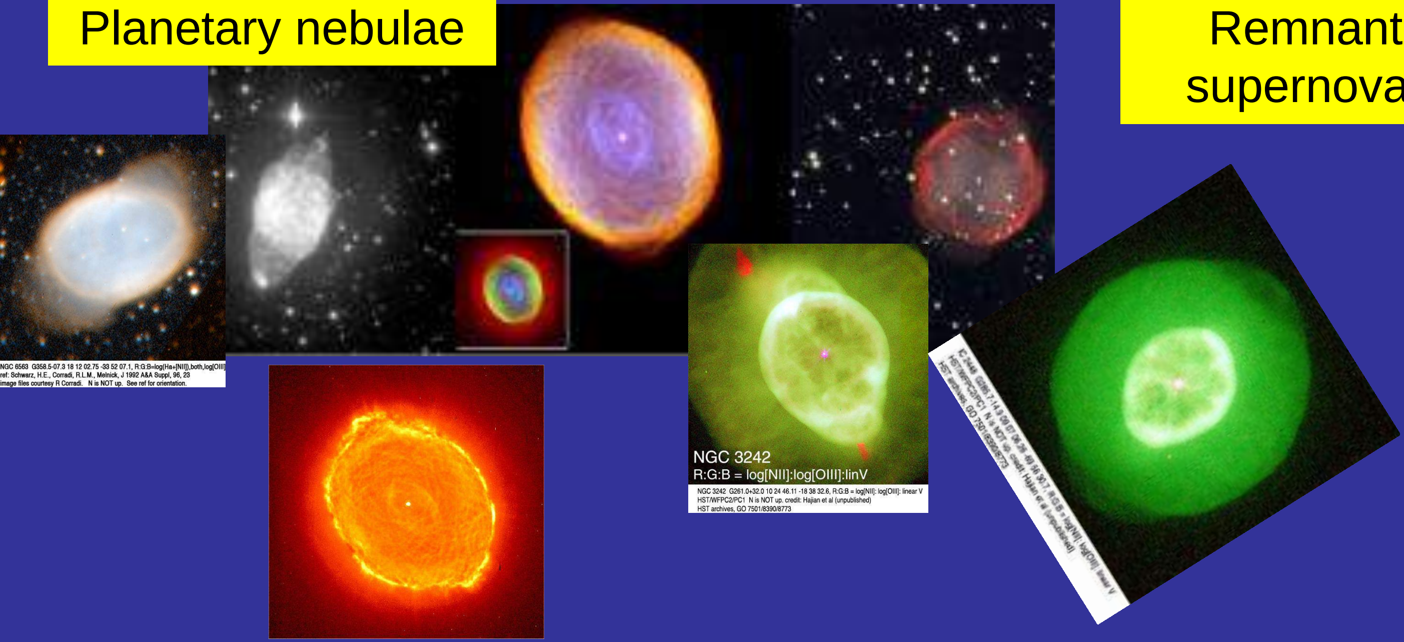


Numerical simulations of a **SN I**nside a **P**lanetary nebula

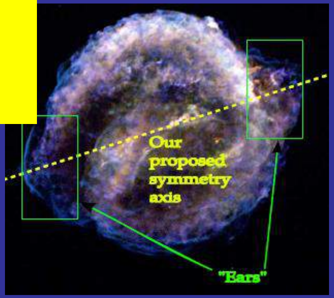
(SNIP)

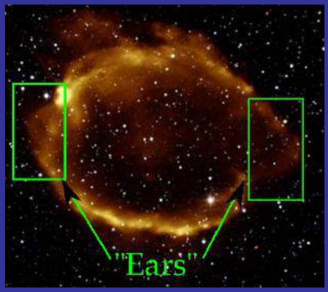
(from Tsebrenko, D. & Soker, N. 2015)

Planetary nebulae



Remnants of supernovae Ia



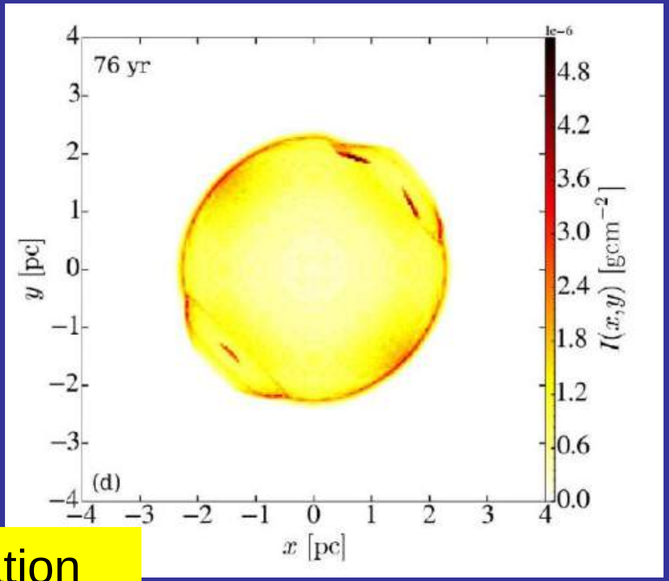


Jets might be common in pre - SN Ia,

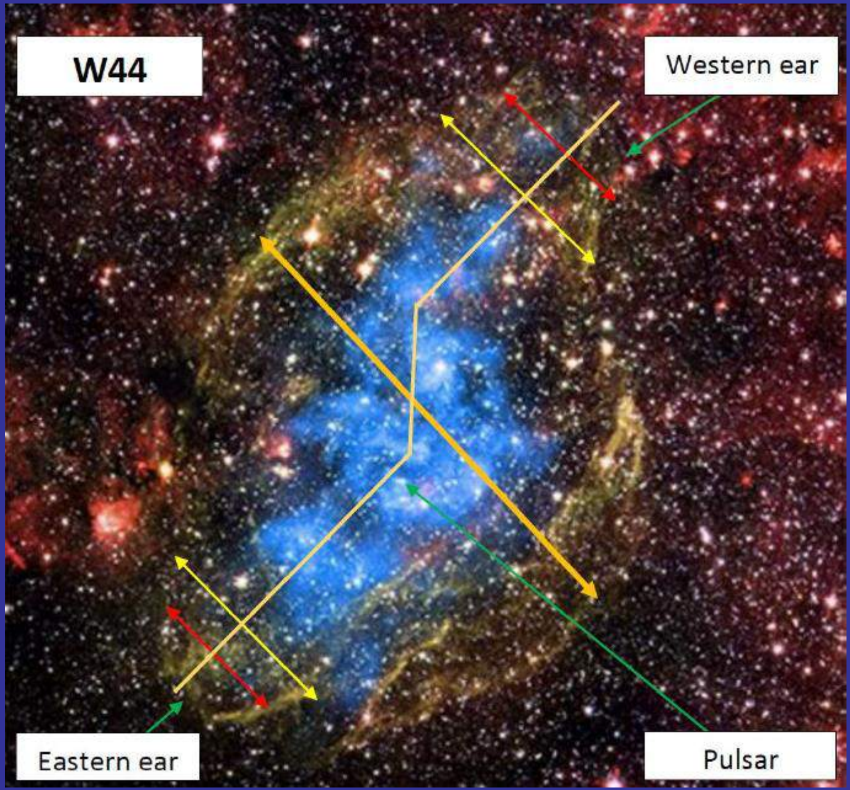
(Tsebrenko & Soker 2013, 2015a)

SNIP: Supernovae Inside Planetary nebulae

(see poster by Aleksander Cikota)



Jets' simulation



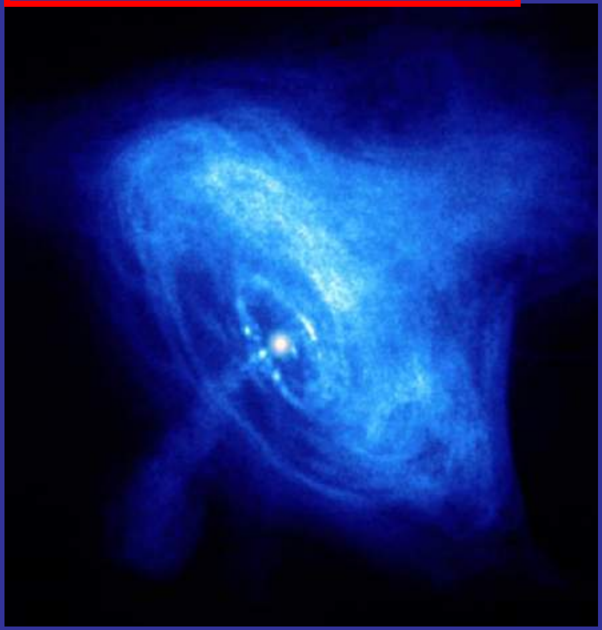
Ears in
Core collapse supernova remnants

Grichener, A. & Soker, N. 2017,
Bear, E. & Soker, N. 2017,
Bear, E., Grichener, A. & Soker, N. 2017

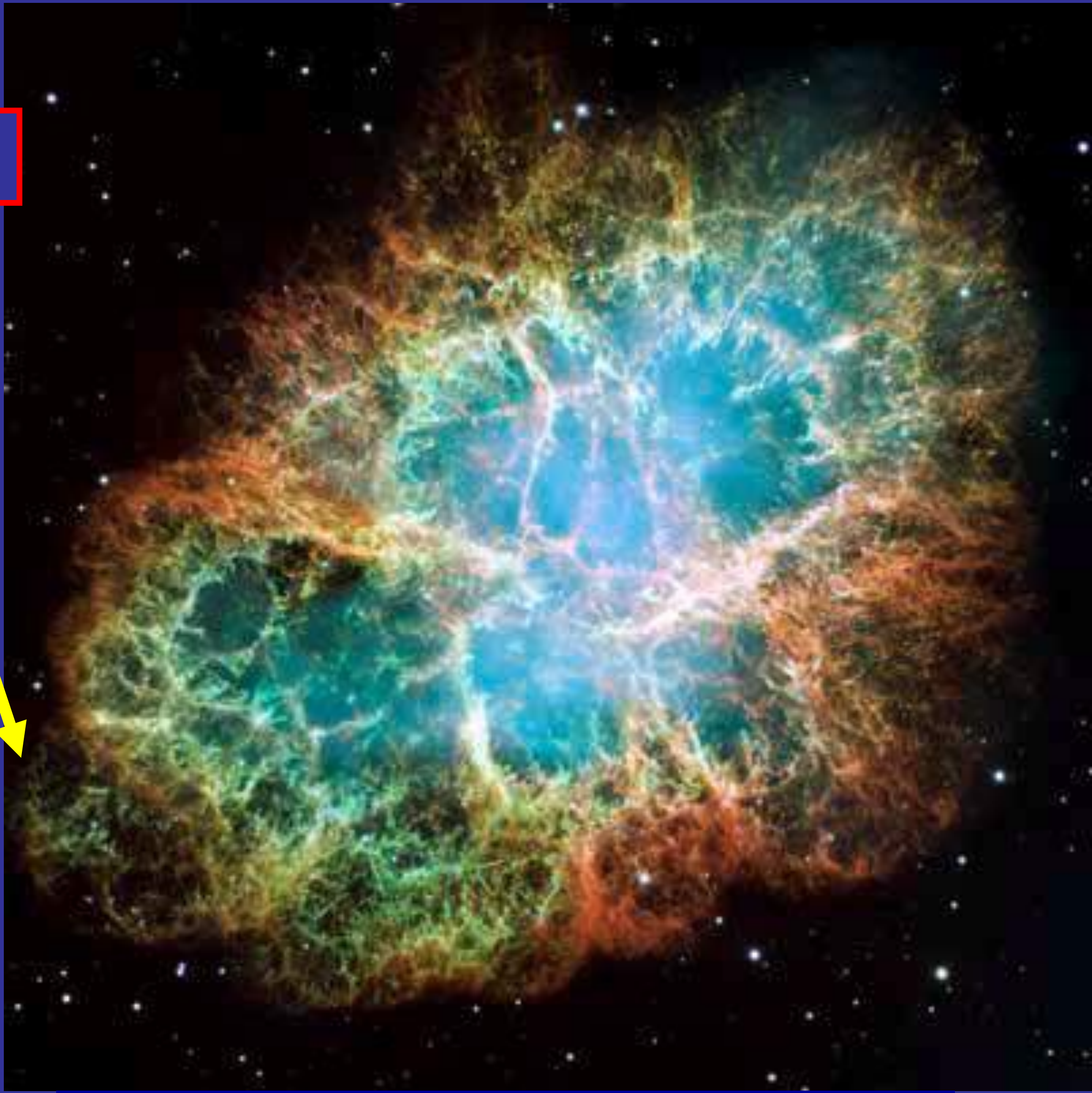
Crab Nebula

An ear

A neutron star with its jets



Credit: NASA/CXC/ASU/J.Hester et al



Credit: NASA, ESA, J. Hester, A. Loll (ASU);
Acknowledgement: Davide De Martin (Skyfactory)

Simeis 147
(V. V. Gvaramadze 2006)

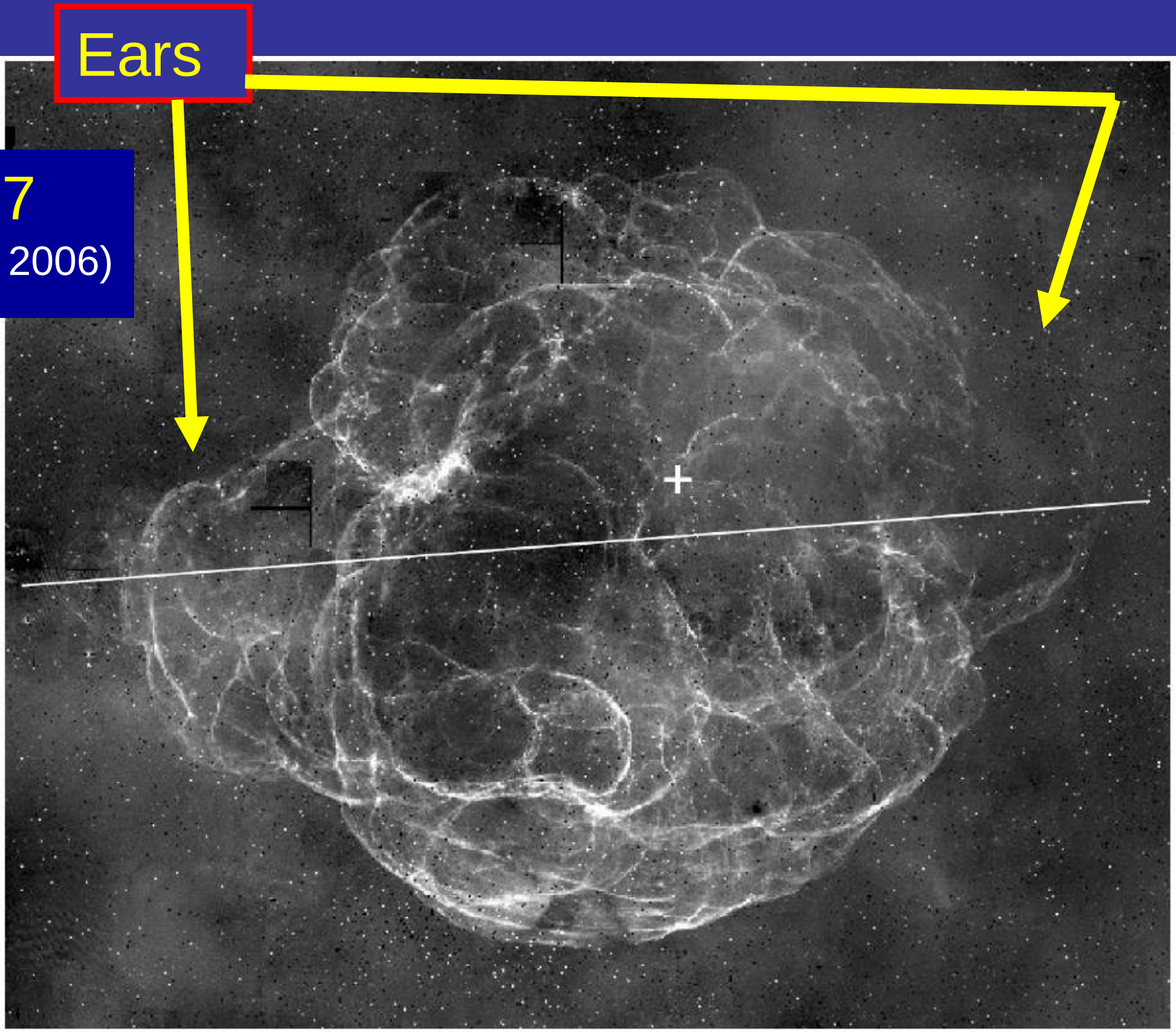
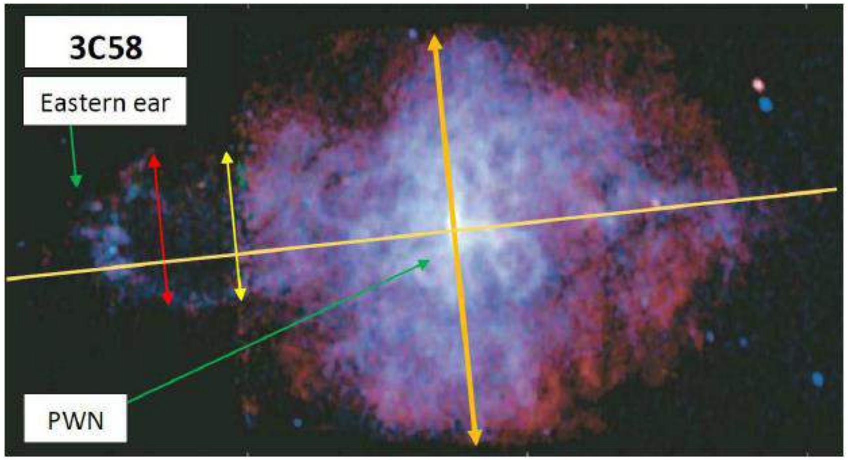
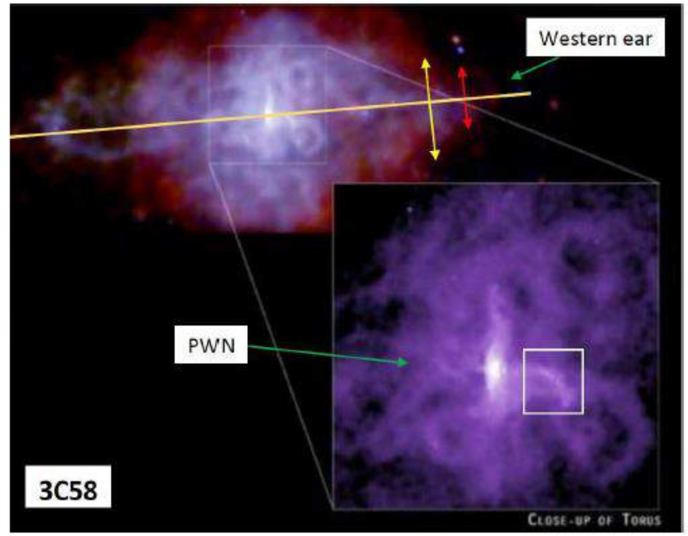
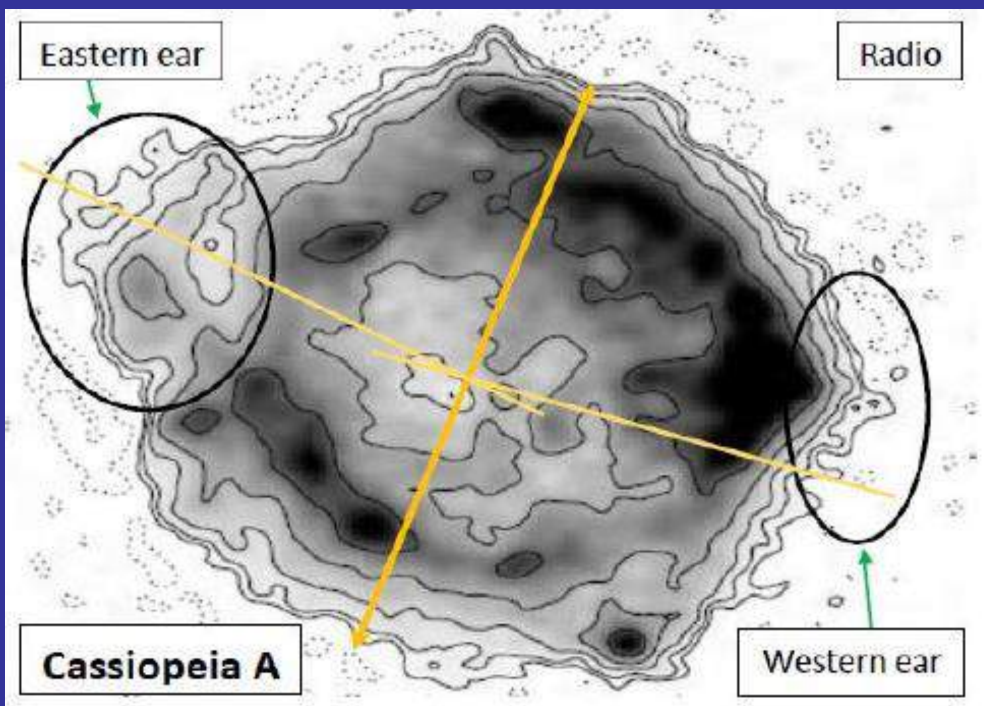
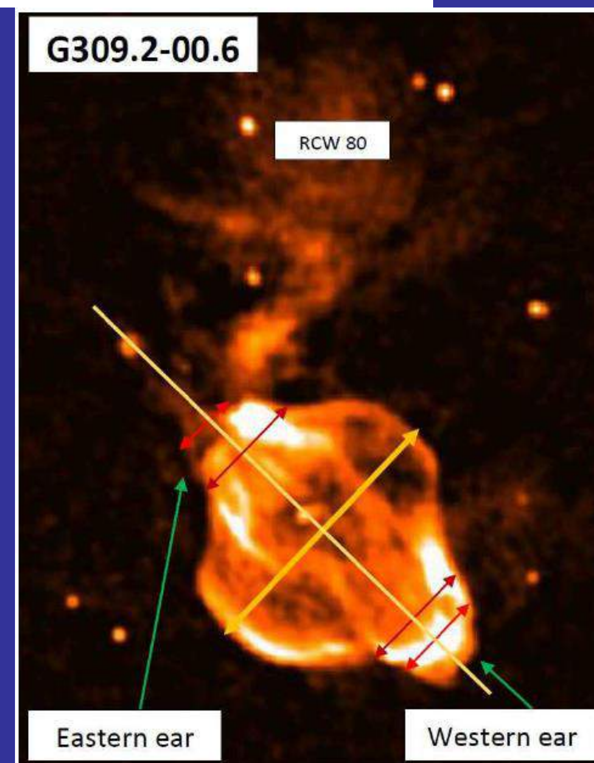


Fig. 1. The H_α image of the supernova remnant S 147 (Drew et al. 2005; reproduced with permission of the IPHAS collaboration). Position of the pulsar PSR J 0538+2817 is indicated by a cross. The line drawn in the east-west direction shows the bilateral symmetry axis (see text for details). North is up, east at left.

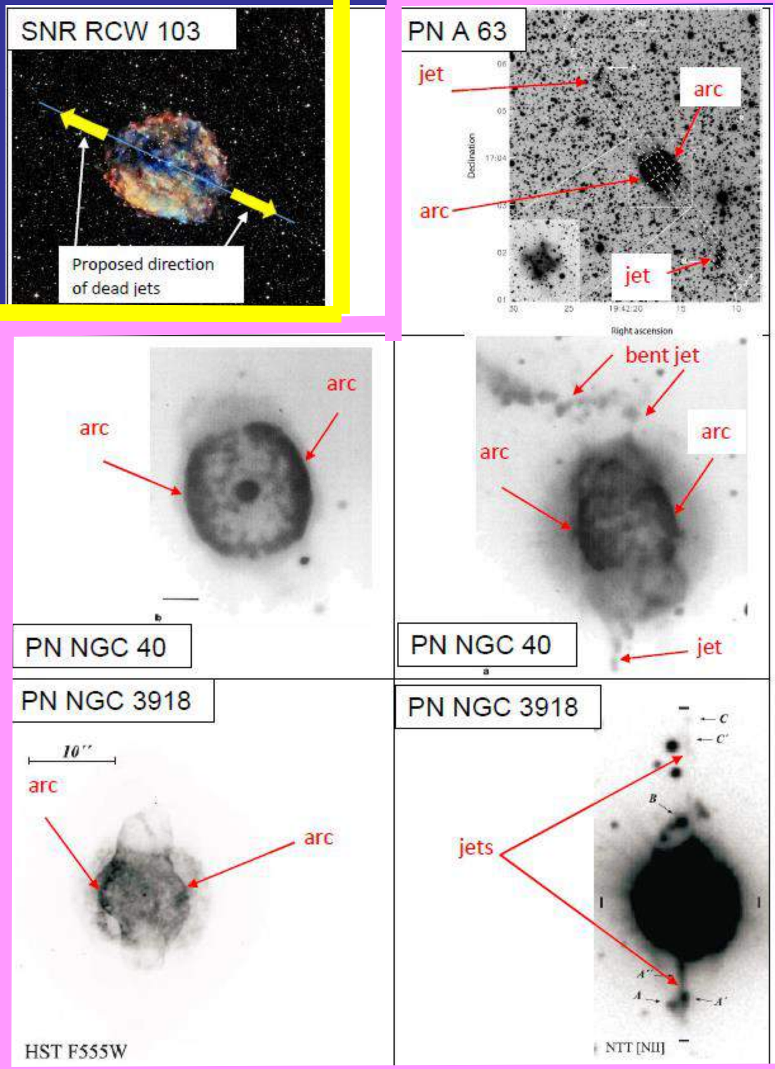

3C58
Eastern ear
PWN


Western ear
PWN
3C58
Close-up of Torus


Eastern ear
Radio
Cassiopeia A
Western ear


G309.2-00.6
RCW 80
Eastern ear
Western ear

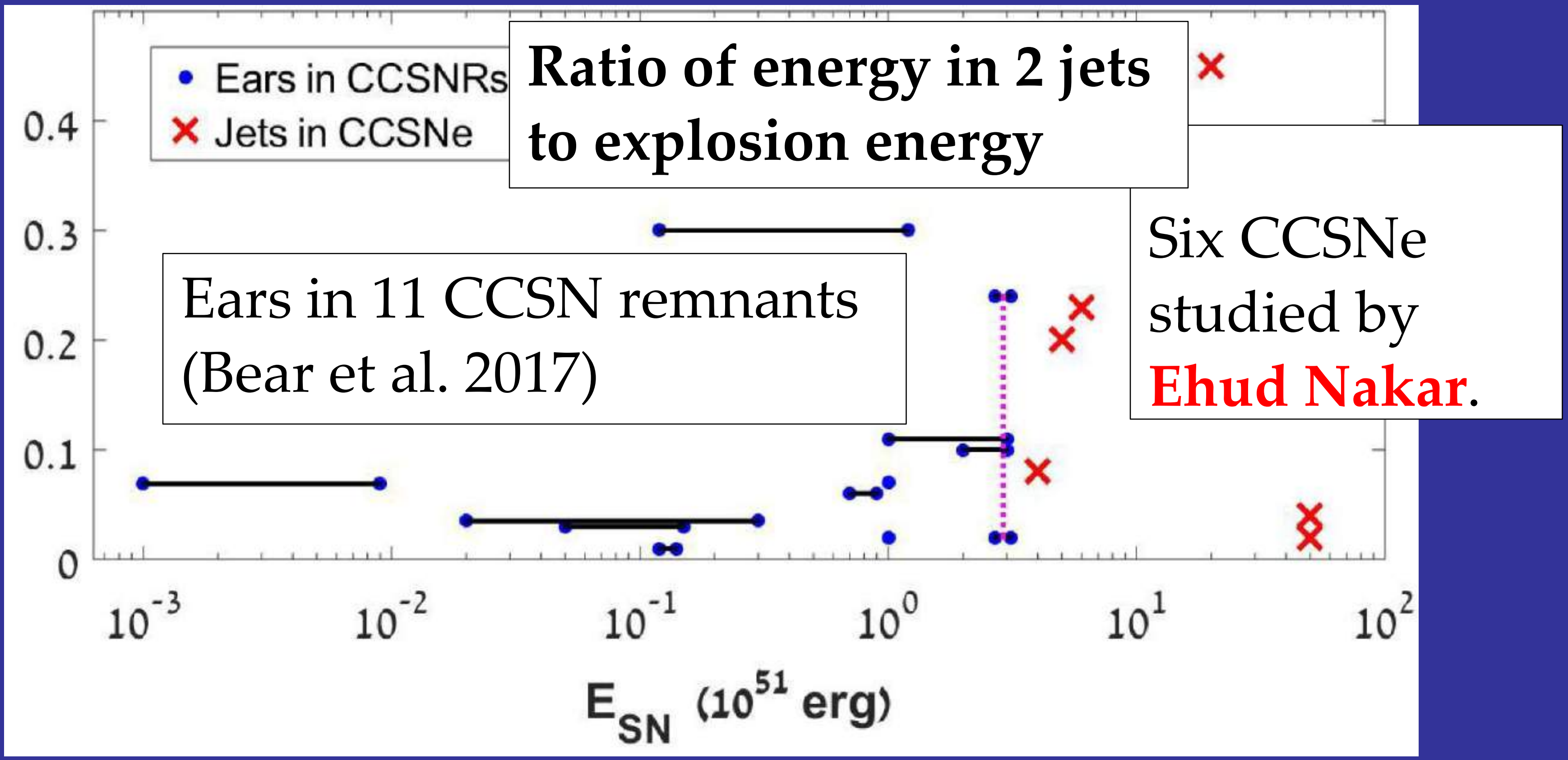
SNR with proposed direction of dead jets



Comparison to planetary nebulae

To take home:

- About 40% core collapse supernova remnants have ears.
- The energy of the jets that inflated the ears is 5-15 % of the explosion kinetic energy.



A summary to that point

I think that all core collapse supernovae are exploded by jets operating in a negative jet feedback mechanism

See review Soker, N., 2016, New Astronomy Review 75, 1
(arXiv:160502672):

"The jet feedback mechanism (JFM) in stars, galaxies and clusters (a review)"

A note

The formation of a magnetar would be accompanied by jets that might carry more energy than the magnetar

Soker, N. 2016, New Astronomy, 47, 88

(paper accepted to the Journal before is was accepted by astro-ph)

Soker, N. 2017

Soker & Gilkis 2017, ApJ, 851, 95

The Necklace planetary nebula (Form Romano Corradi et al. 2011):

A binary central star with P=1.16 days.

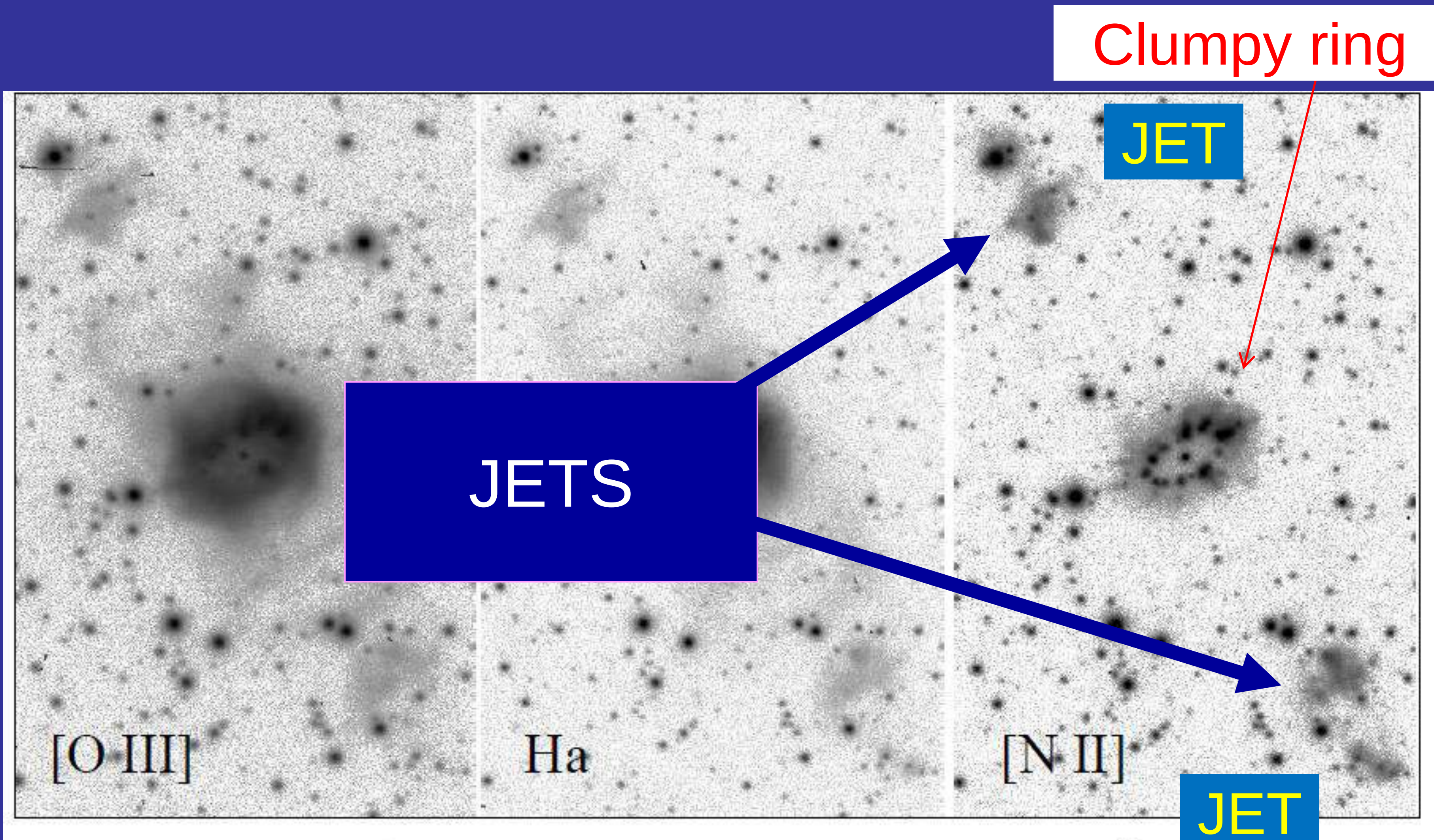
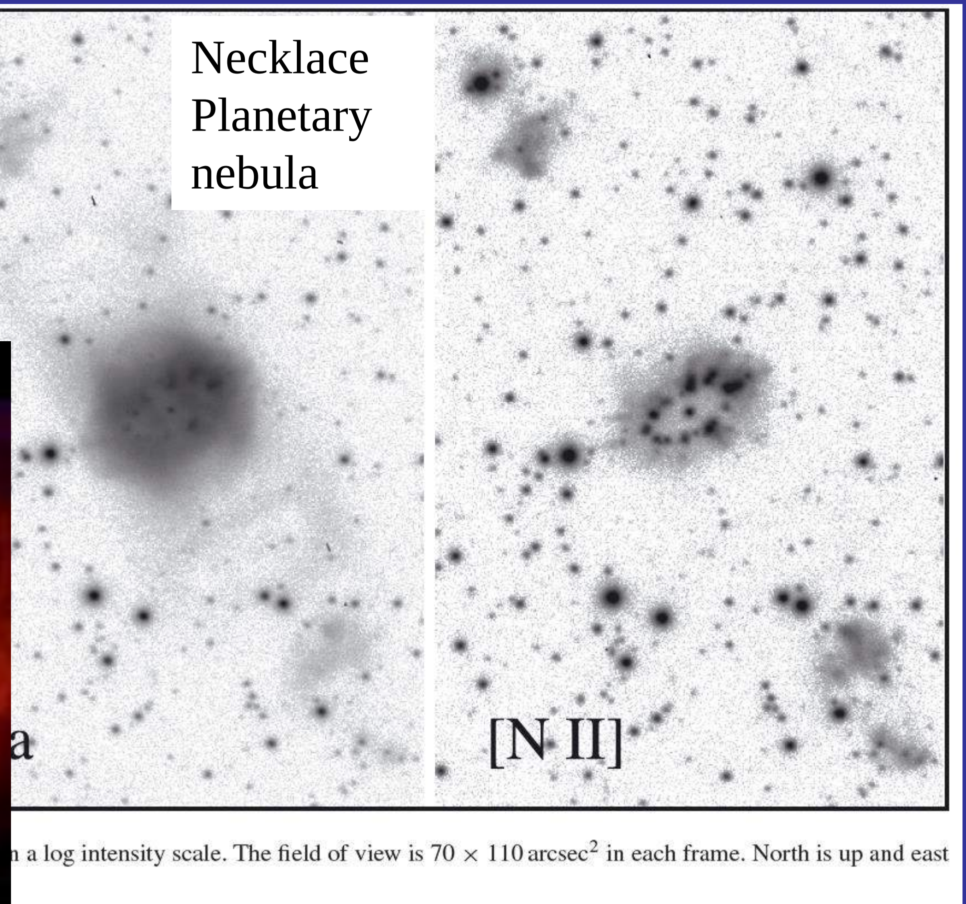


Figure 1. The NOT images of IPHASXJ194359.5+170901 in a log intensity scale. The field of view is 70″×110″ in each frame. North is up and East is left.

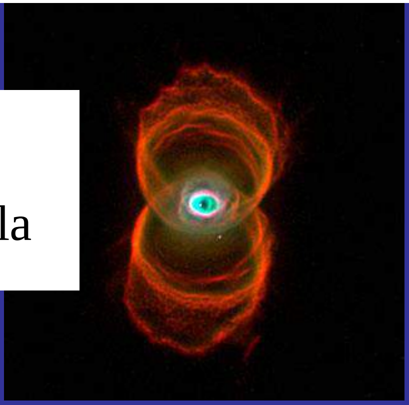
An equatorial dense and clumpy ring



Necklace Planetary nebula

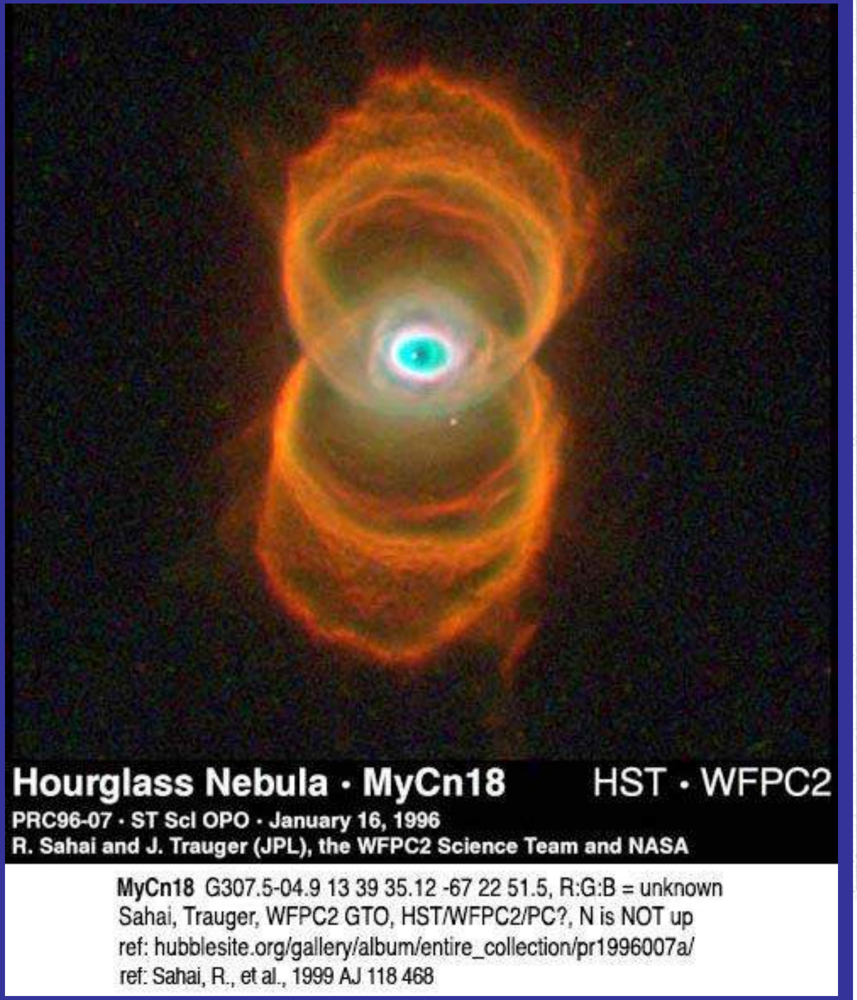
Inner ring in 2004 (HST)

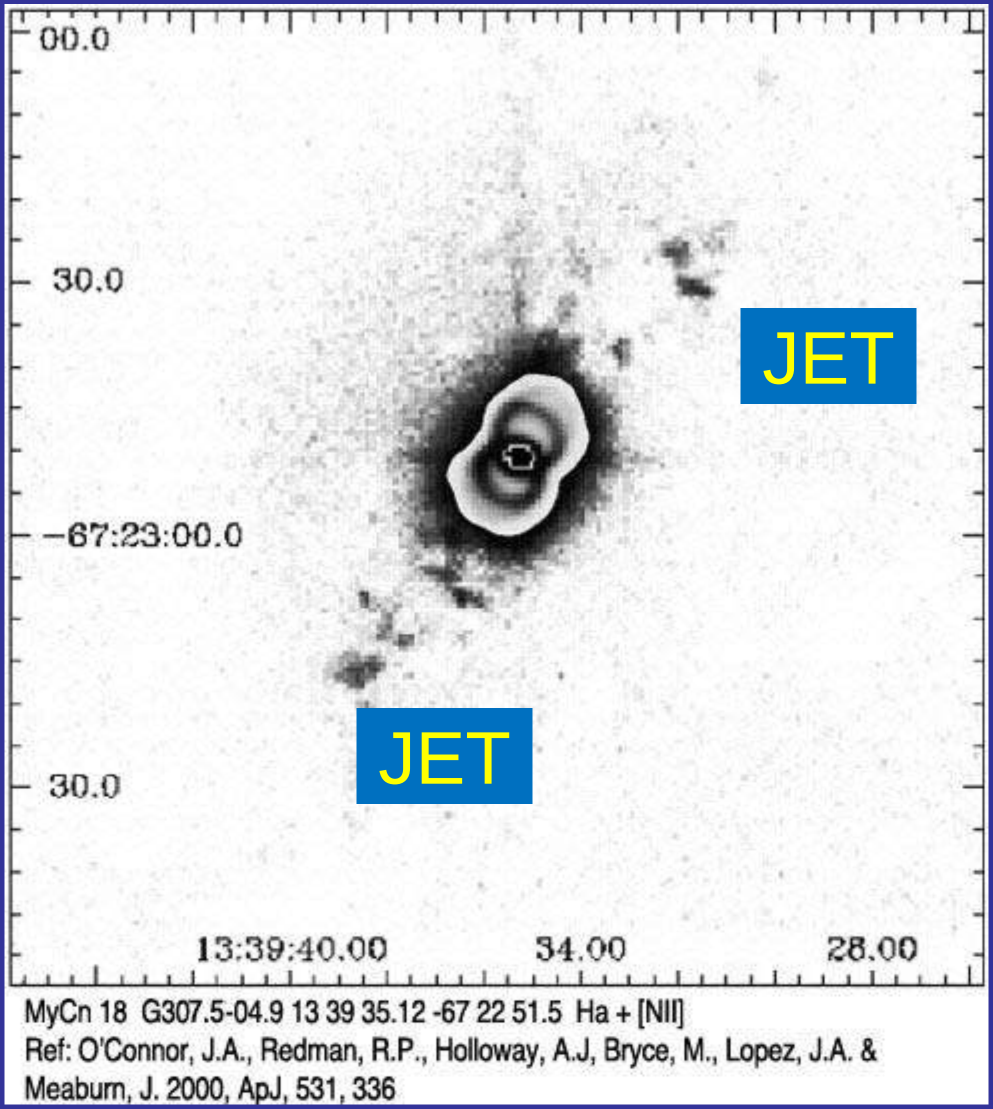
SN 1987A
Supernova remnant



MyCn 18
Planetary nebula

MyCn18 planetary nebula (Form Sahai et al and O'Connor et al.).

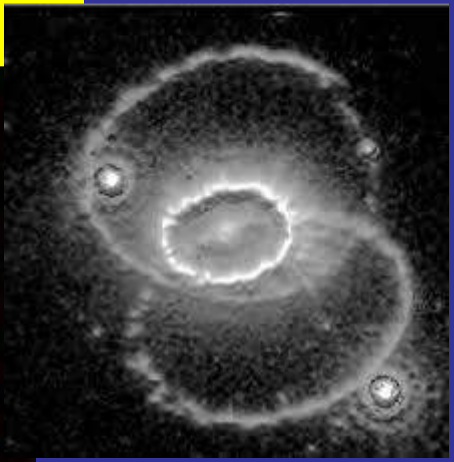




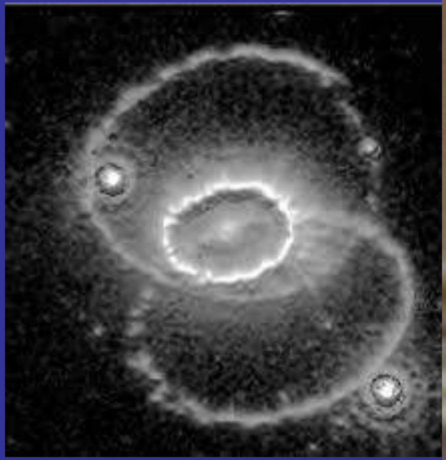
Supernova 1987A evolution (Philipp Podsiadlowski et al.) and the rings (Soker et al.) require binary merger.

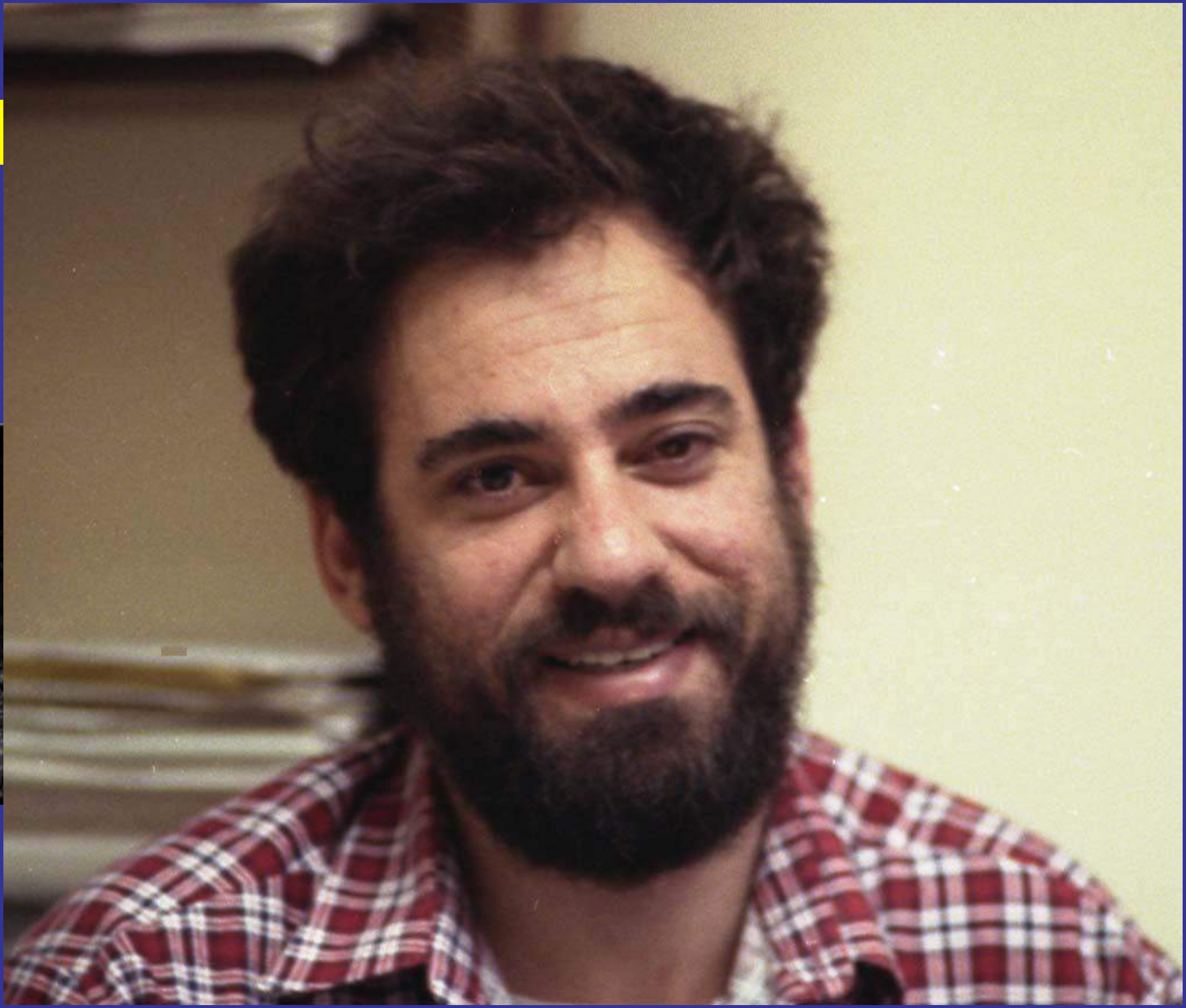
Inner ring in 2004 (HST)

The 3 rings in 1994 (HST)



1987





We now have all that is needed to
summarize the meeting

I summarize the meeting by listing my main conclusions from the talks and posters

(1) Binarity

(Norbert Langer; Selma de Mink; Shane Moran;

Eva Laplace; Teppo Heikkila, Takashi Moriya)

(1.1) Binary companions play a major role in most (or all) enhanced mass loss rate cases

On high mass loss rate before explosion

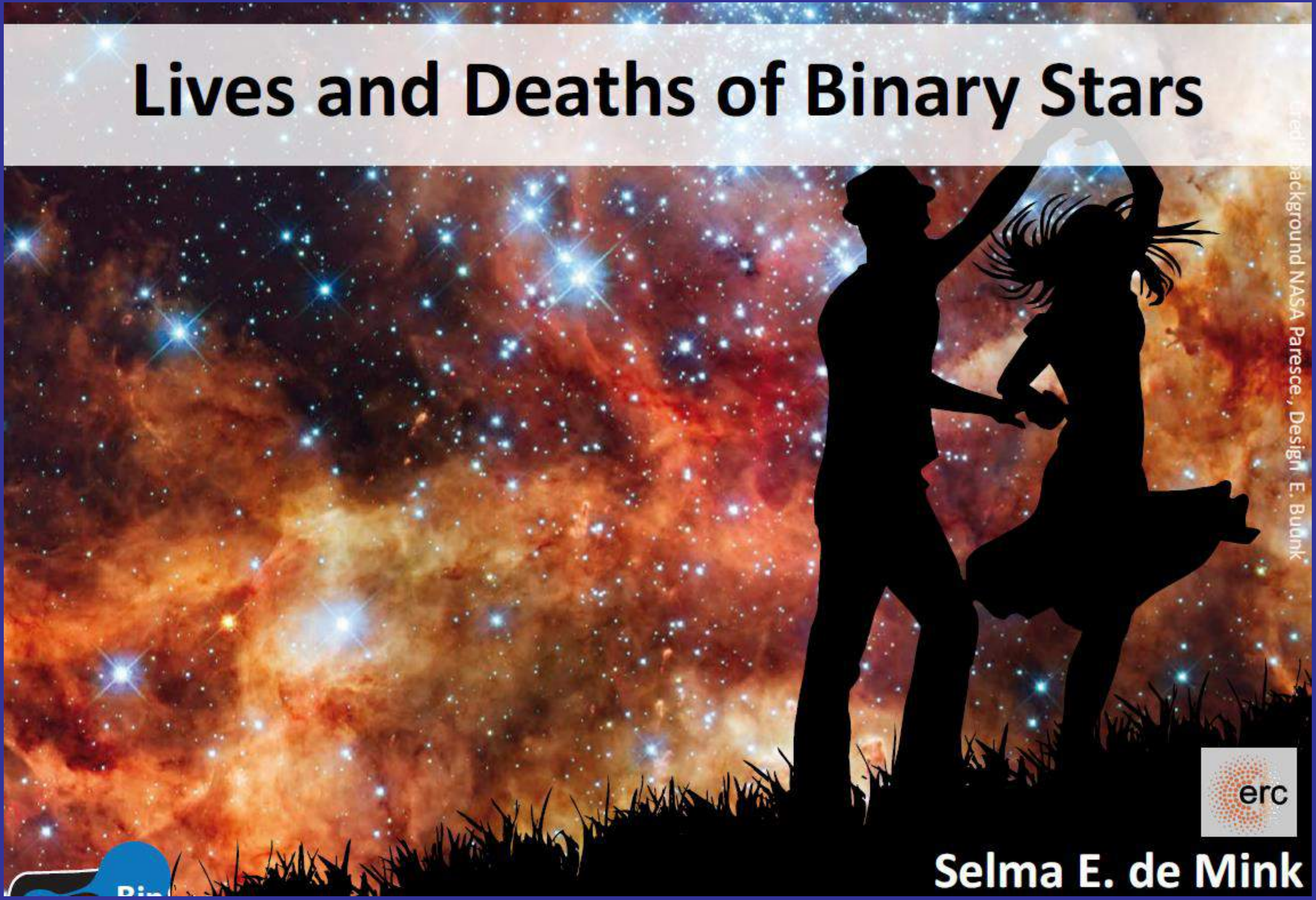
(Francesco Taddia)

(1.2) The rich varieties of SN progenitors comes mainly from the rich variety of binary interaction types (Manos Zapartas;)

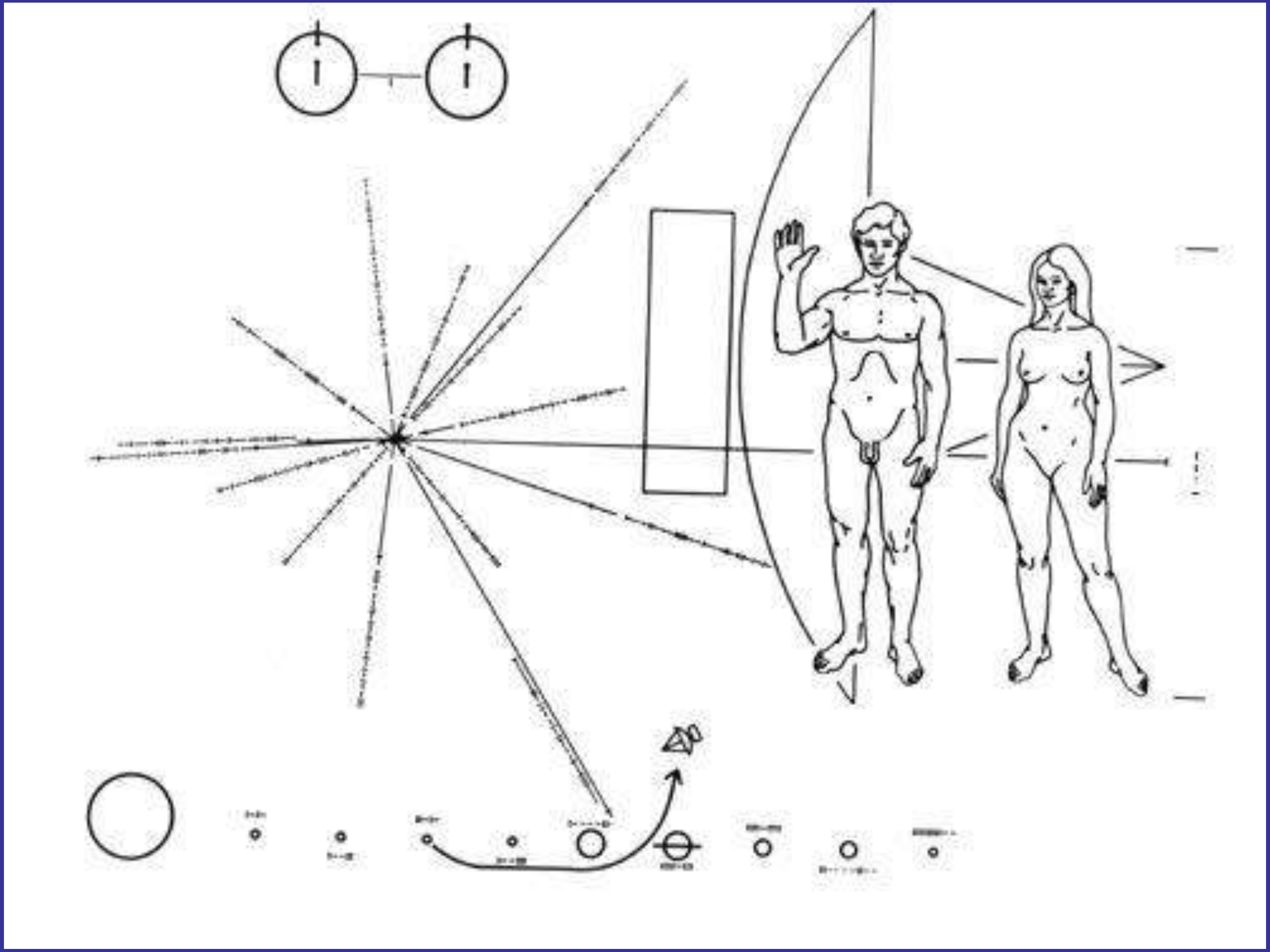
(like I showed for planetary nebulae)

(of course, initial mass important, e.g., Anders Jerkstrand)

The picture that Selma de Mink presents in her binary talks, and . . .



. . . adapted to stripped envelope supernovae



(2) Dust hides many CCSNe

(Charlie Kilpatrick, Erkki Kankare, Jacob Jencson;

Antonia Bevan)

we might miss CCSNe with M>20Mo

(Raya Dastidar)

(3) Many properties of CSM

(as discussed by, e.g., Maayane Soumagnac, Ofer Yaron, Nathan Smith, and posters, Jonathan Quirola, Sebastian Gomez, Emir Karamehmetoglu, Petr Kurfürst, Samaporn Tinyanont, Patrick John Vallely)

are as in planetary nebulae.

All planetary nebulae are shaped by binary, many launching jets.

(4) The delayed neutrino mechanism has generic problems, e.g., it cannot give explosion energy E>2e51 erg, even by scaling.

Simulations have a hard time with E=1e51 erg (Hans-Thomas Janks) or no explosion (Evan O’connor).

(4)

I think the jittering jets explosion mechanism is more promising

For evidence of jets and ears:

Ehud Nakar, David Alexander Kann, Sara Loru, Elise Egron

Not in all cases radio emission is expected

(e.g., no detection: Deanne Coppejans)

SLSNe-I Require jet-driven explosion

(on SLSN: Ragnhild Lunnan; Brian Metzger; Akihiro Suzuki; Ting-Wan Chen)

(4) The delayed neutrino mechanism has generic problems,

It is time that there will also be invited talks on the jets-driven explosion mechanism

(even if the potential speakers are not invited to 60th-birthday parties)

(5) SN 1987A is complicated,

(Josefin Larsson; Yvette Cendes; Marco Miceli)

and might hint on the jittering jets explosion mechanism.

(Bear & Soker 2018)

The clumpy distribution predicted by the neutrino mechanism (Michael Gabler) does not explain all its properties

My suggestion: take clues from planetary nebulae

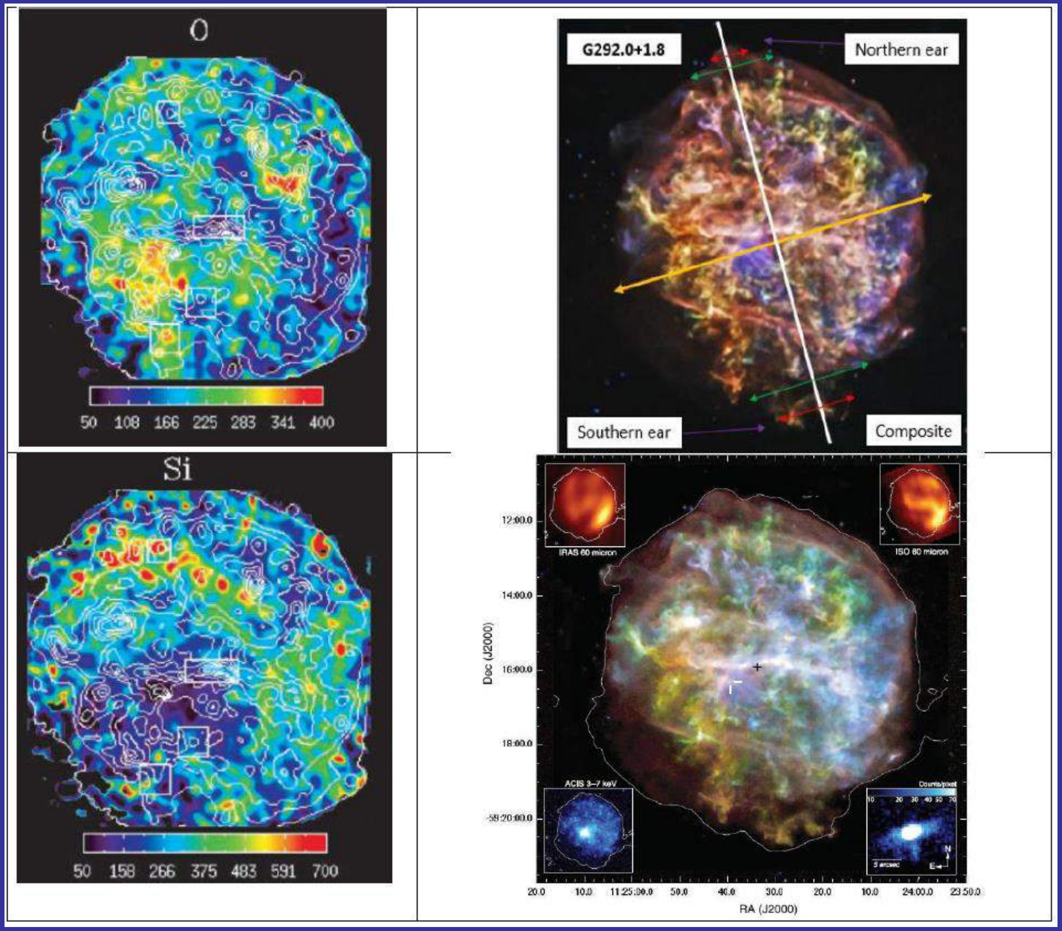
both for the CSM and for the ejecta

(5) SN 1987A is complicated

<u>Step 1:</u>

Compare SN 1987A to CCSN remnants that have clumpy ejecta and show signature of jets

(see Bear & Soker 2018—proofs were sent today to MNRAS)

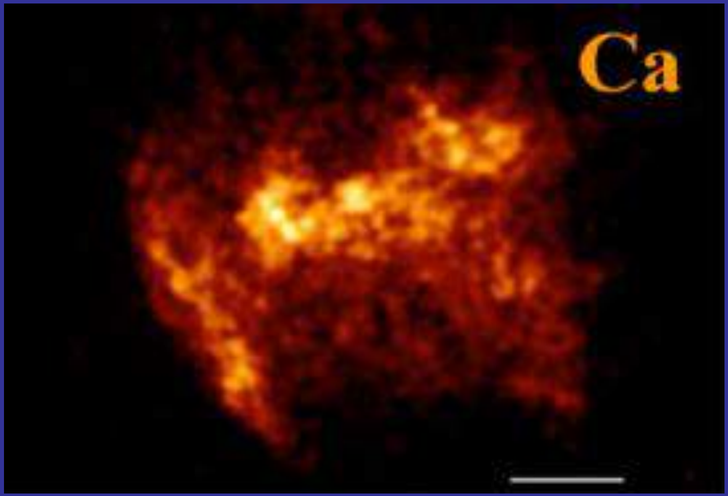


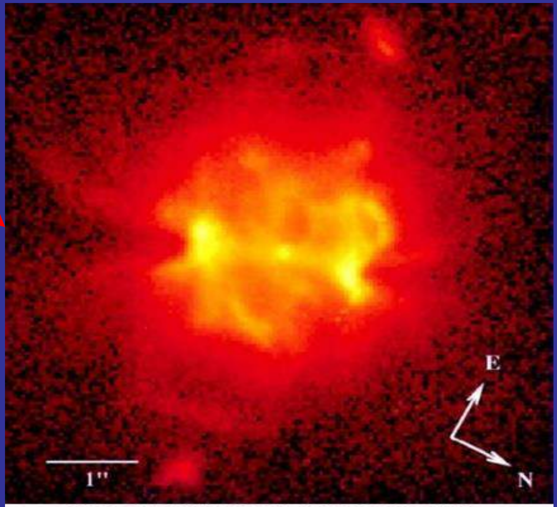
(5) SN 1987A is complicated

Step 2:

Compare these CCSN remnants to planetary nebulae that likely are shaped by jets.

(see Bear & Soker 2018—proofs were sent today to MNRAS)





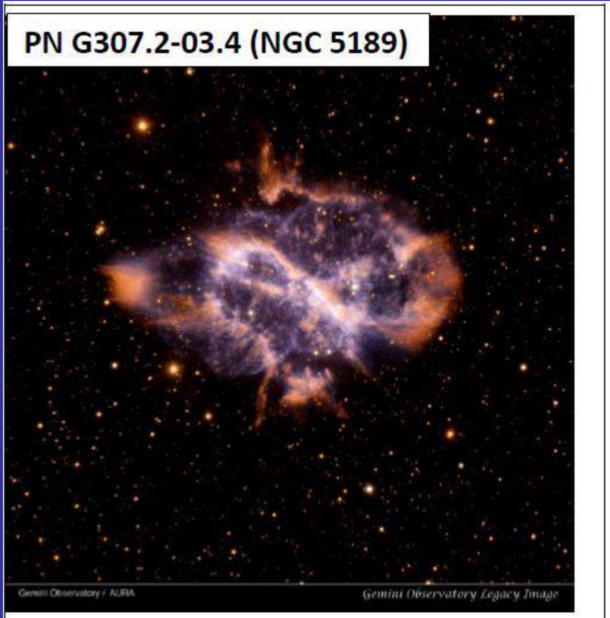
K 3-66 G167.4-09.1 04 36 37.24 +33 39 29.9, R:G:B = Halpha
HST/WFPC2/PC1 N is NOT up. HST archives, GO 6353
credit: R. Sahai & J. Trauger 1998 AJ, 116 1357

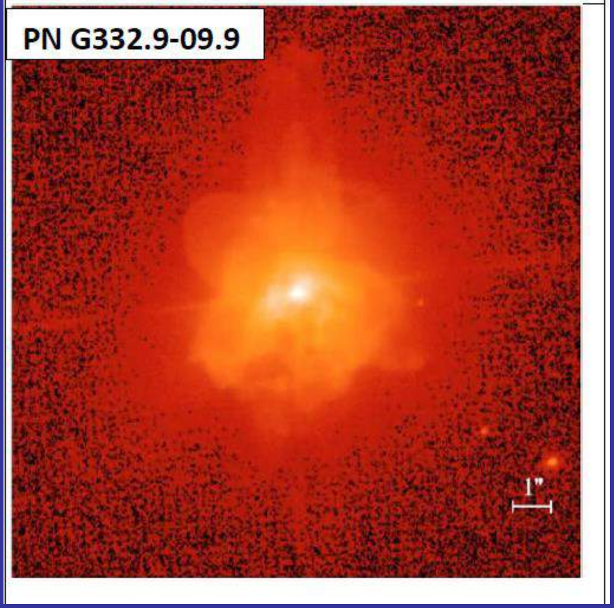
(5) SN 1987A is complicated

<u>Step 3:</u>

Take `messy' planetary nebulae that are shaped by jets.

(see Bear & Soker 2018—proofs were sent today to MNRAS)





(6) Dense CSM is common
and ejecta-CSM interaction crucial

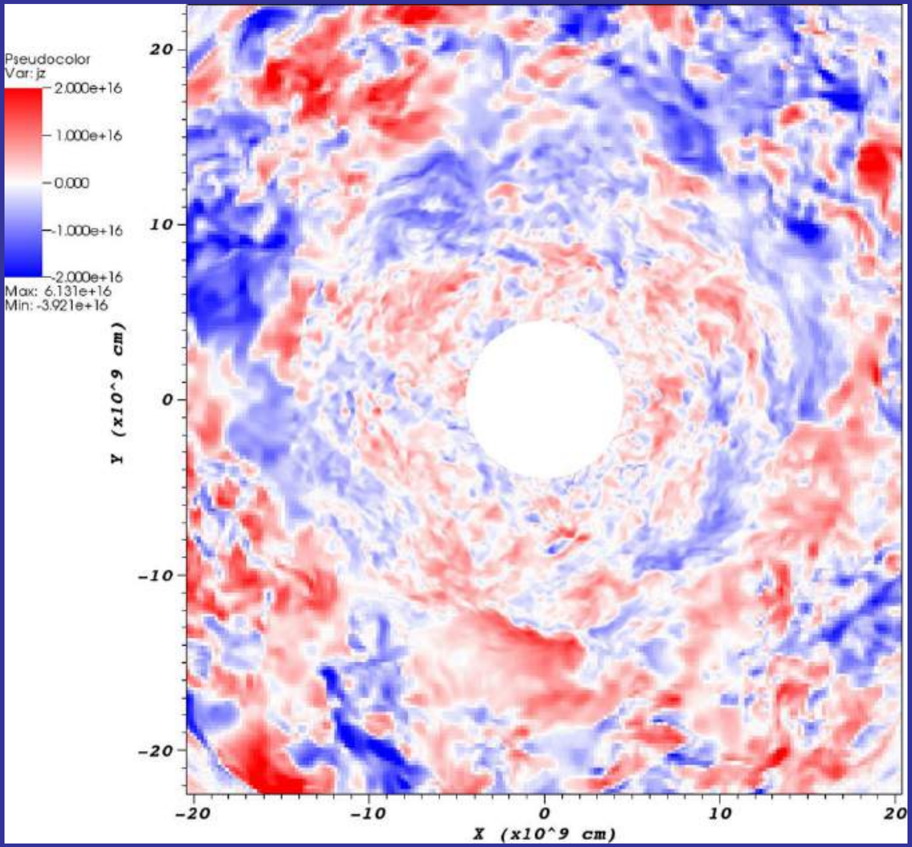
(e.g., Ori Fox; Tamas Szalai; Alak Ray; Niloufar Afsari; Kelsie Krafton; A. J. Nayana; Eran Ofek; Anders Nyholm; Andrea Pastorello; Hanindyo Kuncarayakti; Maria Drout; Esha Kundu).

sometimes with periodic variations (Stuart Ryder)

Asymmetrical structures of the CSM are crucial

(e.g. Maayane Soumagnac; Takashi Nagao; Antonio Tutone)

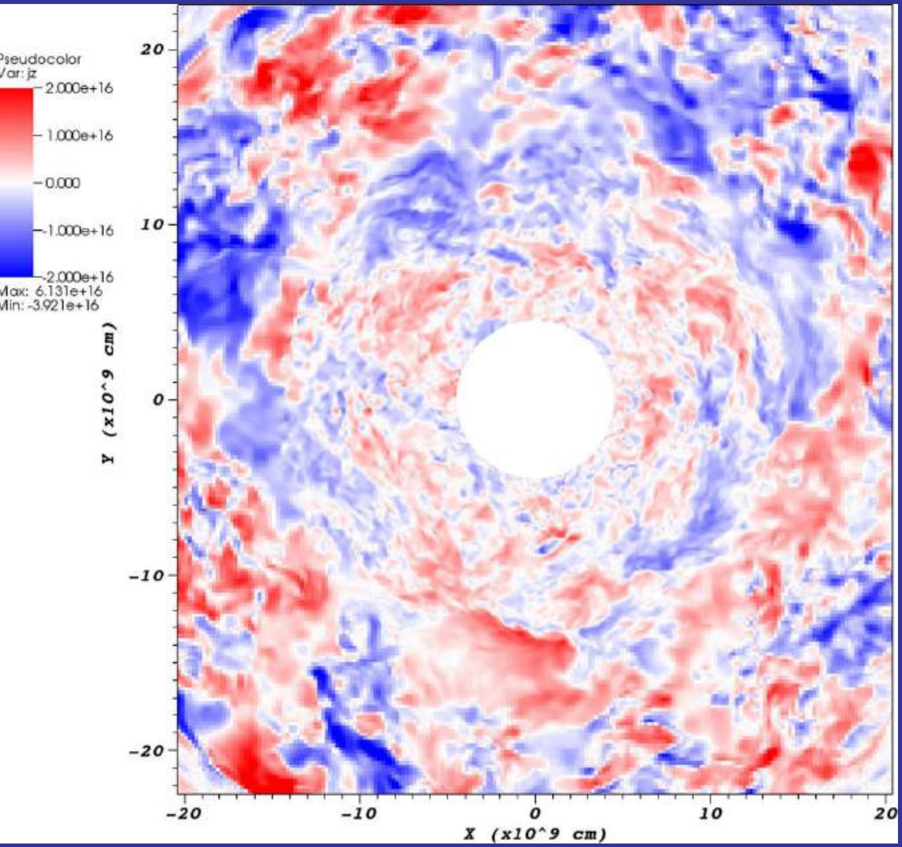
Angular momentum in the helium shell of a massive star.



This strong convection with large scale structures can lead to stochastic accretion of angular momentum, and when take place in the C,Ne,O,Si, shells can as well lead to energy deposited to the envelope

[by waves (Quataert & Shiode 2012), and/or magnetic activity (Soker & Gilkis 2017)].

(picture from Gilkis & Soker 2016).



Angular momentum in the helium shell of a massive star.

Energy deposition before explosion can lead to mass loss (poster by Ryoma Ouchi),
and to envelope expansion that engulfs a companion that then launches jets, including cases with a neutron star companion (poster by Avishai Gilkis).

Enigmatic iPTF2014hls (Yair Arcavi):
Soker & Gilkis (2018) suggest a neutron star launching jets inside an envelope

common envelope jets supernova

(6) CSM in Pulsational pair-instability supernovae

(e.g. Ken'ichi Nomoto, Robert Farmer, Mathieu Renzo)

(7) Talks and posters on physical processes.

(Anatoly Spitkovsky; Elad Steinberg; Roger Chevalier; A.J. Nayana; Tamar Faran, Kohta Murase)

(8) Massive CSM around some SN Ia
I think this supports the Core Degenerate Scenario

(Vikram Dwarkadas; Aleksander Cikota)

Other scenarios explain peculiar and rare event (Kate Maguire;

Ji-an Jiang on the double-detonation scenario)

Meeting Summary

- Jets (before, during, after explosion)
- Binary systems
- Relation to low mass binary systems

I thank the organizers for allocating me the last talk, hence enabling me to summarize the meeting and motivating me to post my Summary Poster every day.

* Let me know if you want the file of my Summary Poster