Magnetic Fields in Supernova Remnants and Pulsar-Wind Nebulae

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Which contents I will cover…

- Shell Supernova Remnants: Obliquity Dependence, and Summary!
- Magnetic Fields in Pulsar-Wind Nebulae.
- Usually, a review paper will let you know a little, but make you feel more confused…
- I hope I will not make you feel “more more” confused!

Shell SNR Summary

- 1. From radio observations, equipartition values of magnetic field strength are in the $\sim$10 μG range, but there is little physical motivation to assume equipartition.
- 2. Radio polarization studies show that in young SNRs, the magnetic field is largely disordered, with a small radial preponderance. In older, larger SNRs, the field is often disordered but sometimes tangential.
- 3. Curvature (spectral hard … erved in the radio spectra of Tycho and Kepler. A nonlinear shock a … s with magnetic field strengths of 0.1–1 mG (average over the emit …
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- 5. Brightening and fading … in G347.3-0.5 and Cas A require B $\sim$ 1 mG, if they represent acce … ns. Fields smaller by a factor of several are possible if the fluctuations are due to strong magnetic turbulence.

- 6. Large azimuthal variations in the rolloff frequency in SN 1006 and G1.9+0.3 are difficult to explain for a conventional picture of loss-limited acceleration in parallel shocks.
- 7. For Cas A, the detection at GeV energies with Fermi requires B~0.1 mG to avoid overproducing the GeV emission with electron bremsstrahlung.
- 8. TeV emission seen in four shell SNRs is not well explained by either leptonic or hadronic processes. However, if it is hadronic, the magnetic fields implied are of order 100 μG,while leptonic models require much lower fields.

Shell SNR conclusion

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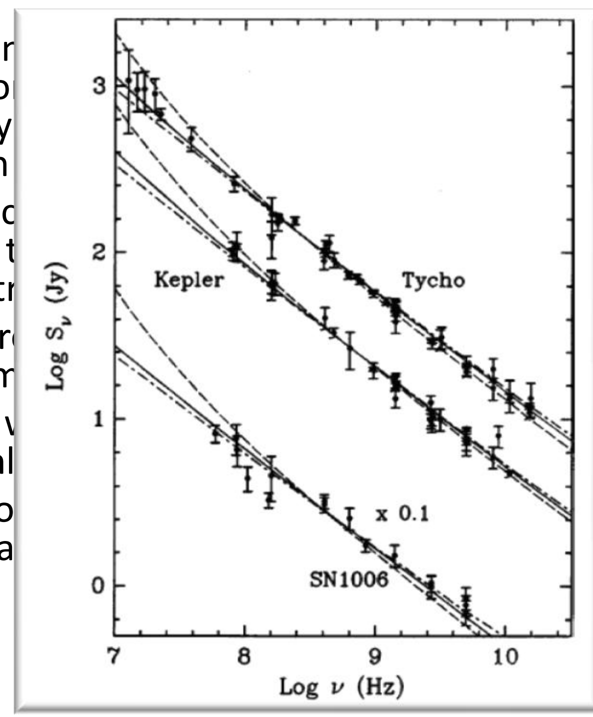

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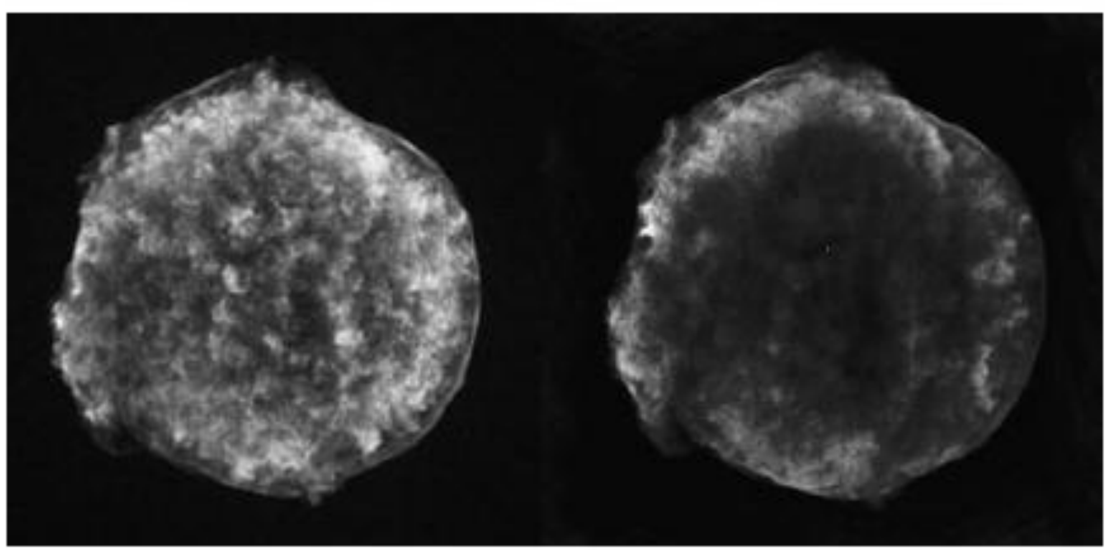

Fig. 7 *Left*: *Chandra* image of Tycho's SNR (CXC). *Right*: VLA image at 1420 MHz (Reynoso et al. 1997). Note the thin rims in the X-ray image (e.g., NE quadrant), with some thin radio rims as well

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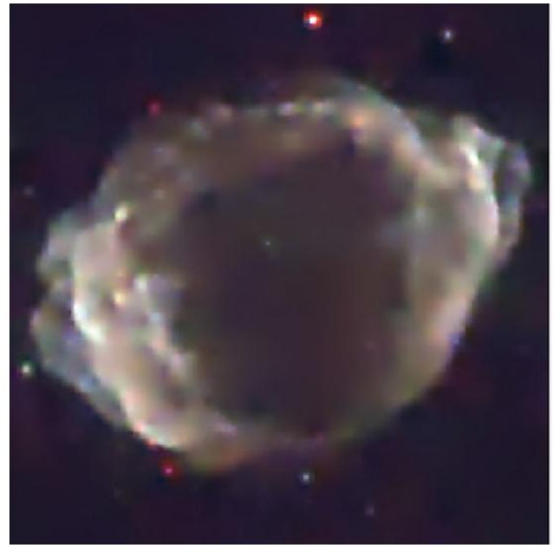
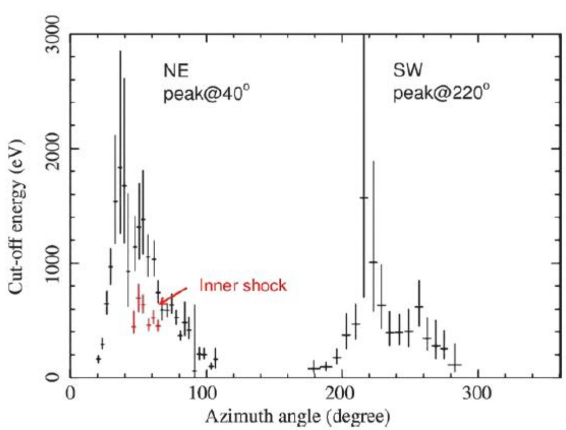
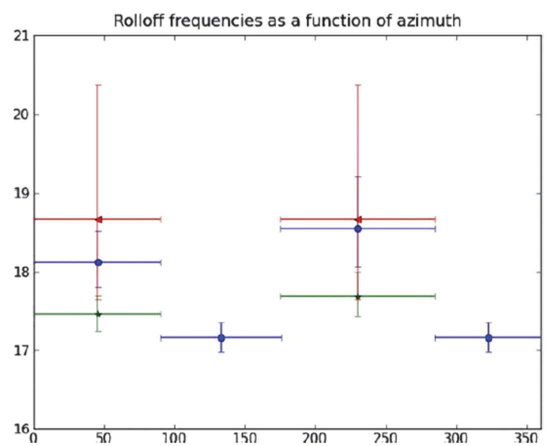
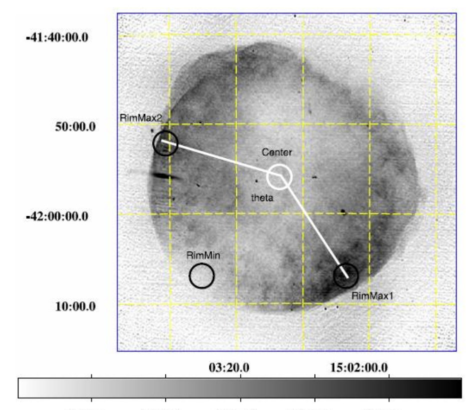
Obliquity Dependence









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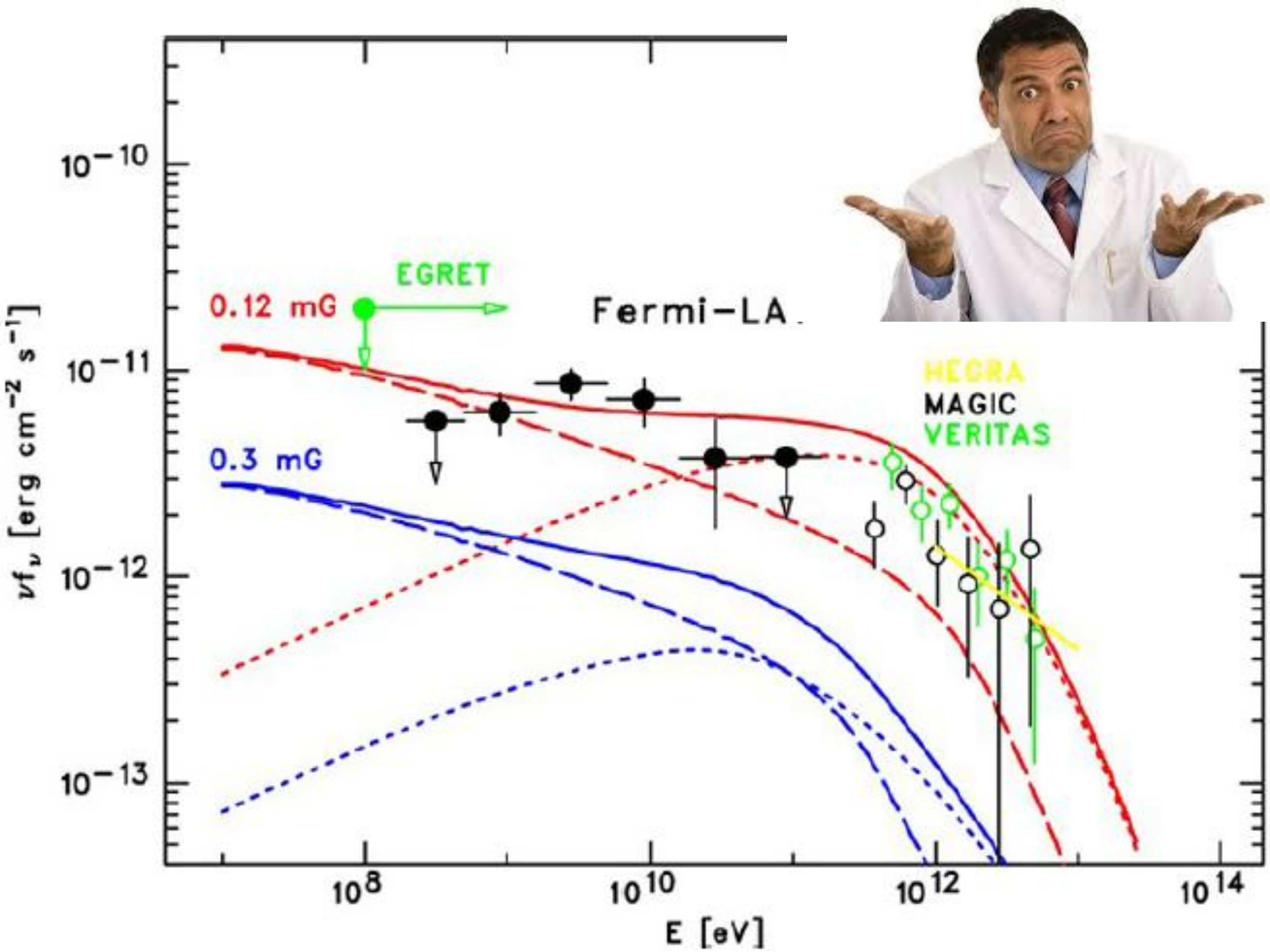

Spectrum of GeV emission from Cas A as seen by Fermi (Abdo et al. 2010a). The solid curves are leptonic models (dots, IC; dashes, bremsstrahlung) with magnetic-field values shown.

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What are you talking about....

Magnetic Fields in PWN

PWN?

SNR?

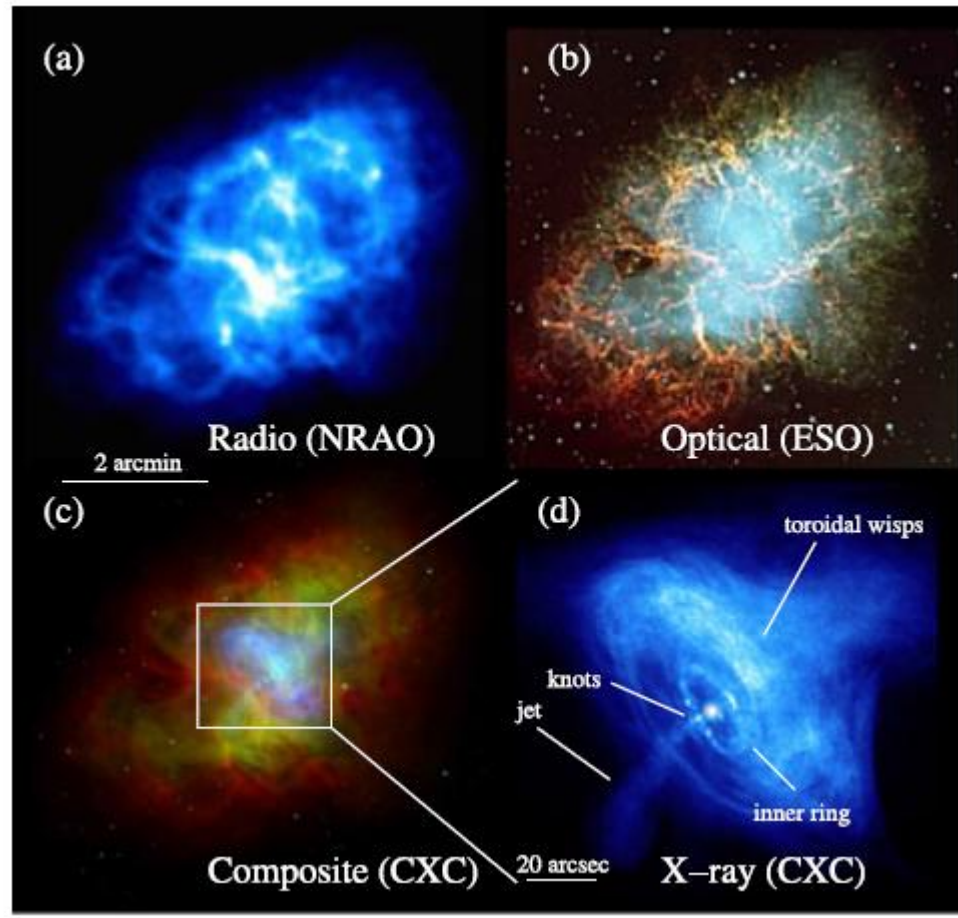
CRAB?

Definitions are always boring…

Please pay a litttttttttle attention…

PWNe vs. SNRs

- Energy Source
- Radio Morphology
- Radio Spectral Index
- Angular Extent
- Fractional Polariza-
  tion

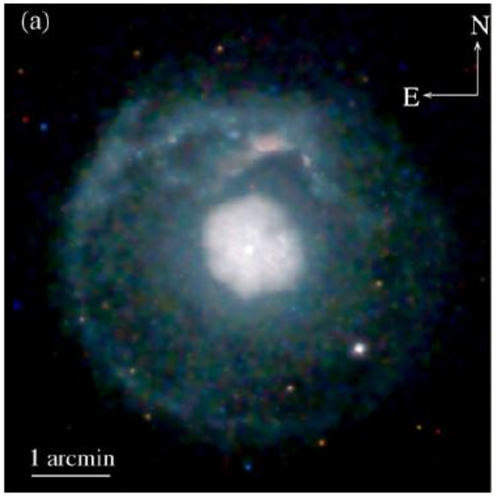


PWNe vs. SNRs

- Energy Source
- SNRs result from an essentially instantaneous deposition of energy, in the form of a blast wave driven into the ISM by a supernova explosion.
- PWNe have a continuous power source, the bulk relativistic flow of electron/positron pairs from an energetic neutron star.

PWNe vs. SNRs

- Radio Morphology
- SNRs are usually limb-brightened shells of synchrotron emission
- PWNe are typically amorphous or filled-center synchrotron nebulae brightest at the pulsar’s position.



PWNe vs. SNRs

- Radio Spectral Index: $S \propto \nu^{\alpha}$.
- SNRs usually have relatively steep radio spectral indices, $\alpha \approx 0.3$–0.8.
- *PWNe have spectral indices in the range,* $\alpha \approx 0$–0.3.

PWNe vs. SNRs

- Angular Ext
- SNRs are lo
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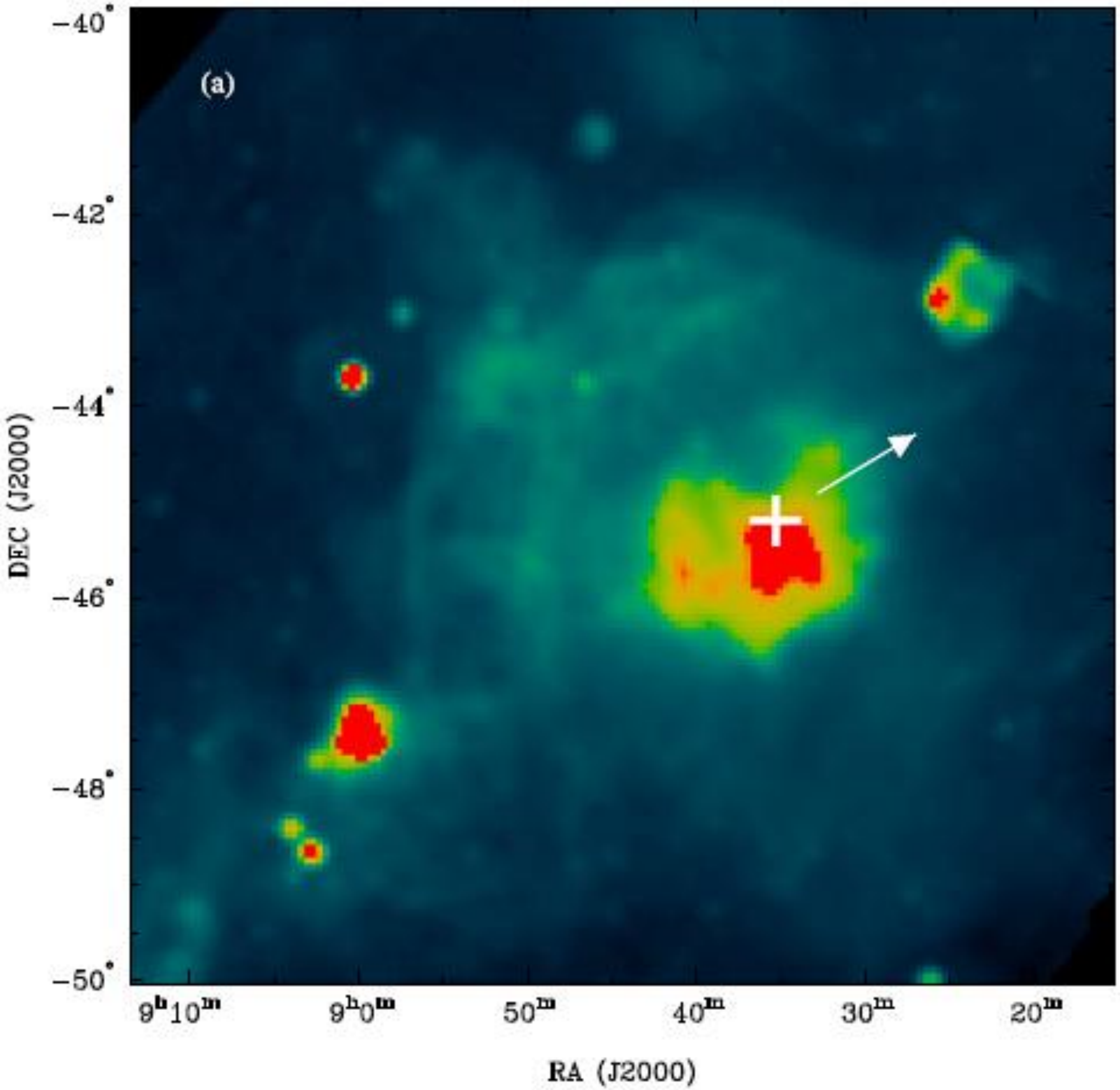
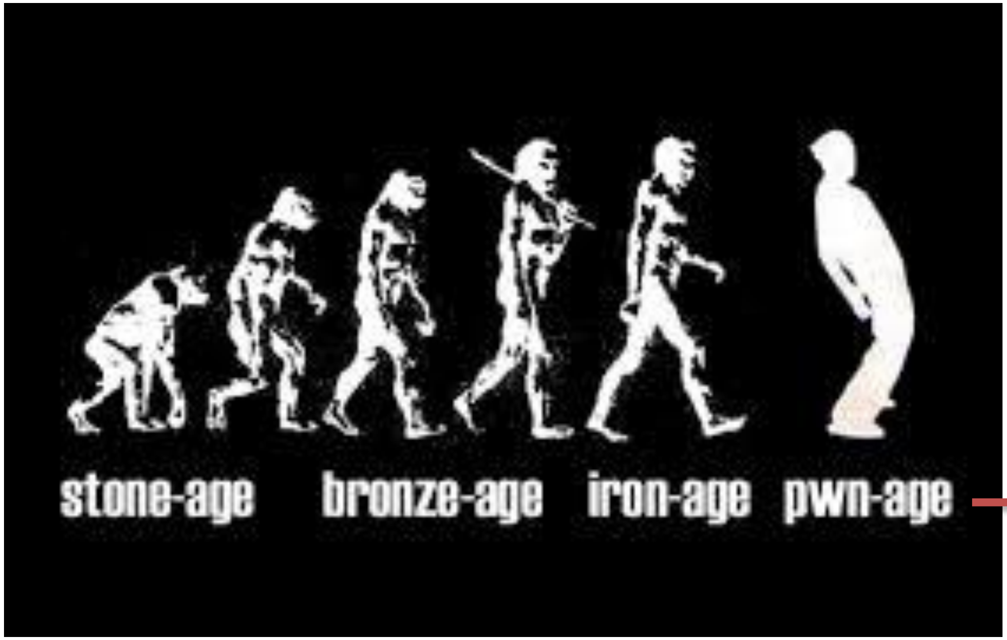
  to >5 $^\circ$.
- *PWNe* are u
  the range 1(
  PWNe may



PWNe vs. SNRs

- Fractional Polarization
- At radio frequencies near 1 GHz, SNRs typically have modest amounts of linear polarization, at the level of 5%–10%.
- PWNe usually have very well organized magnetic fields, with correspondingly higher polarization fractions, in the range 30%–50%.

PWN Evolution



the word "pwn" which is a typographical error of the word "own"

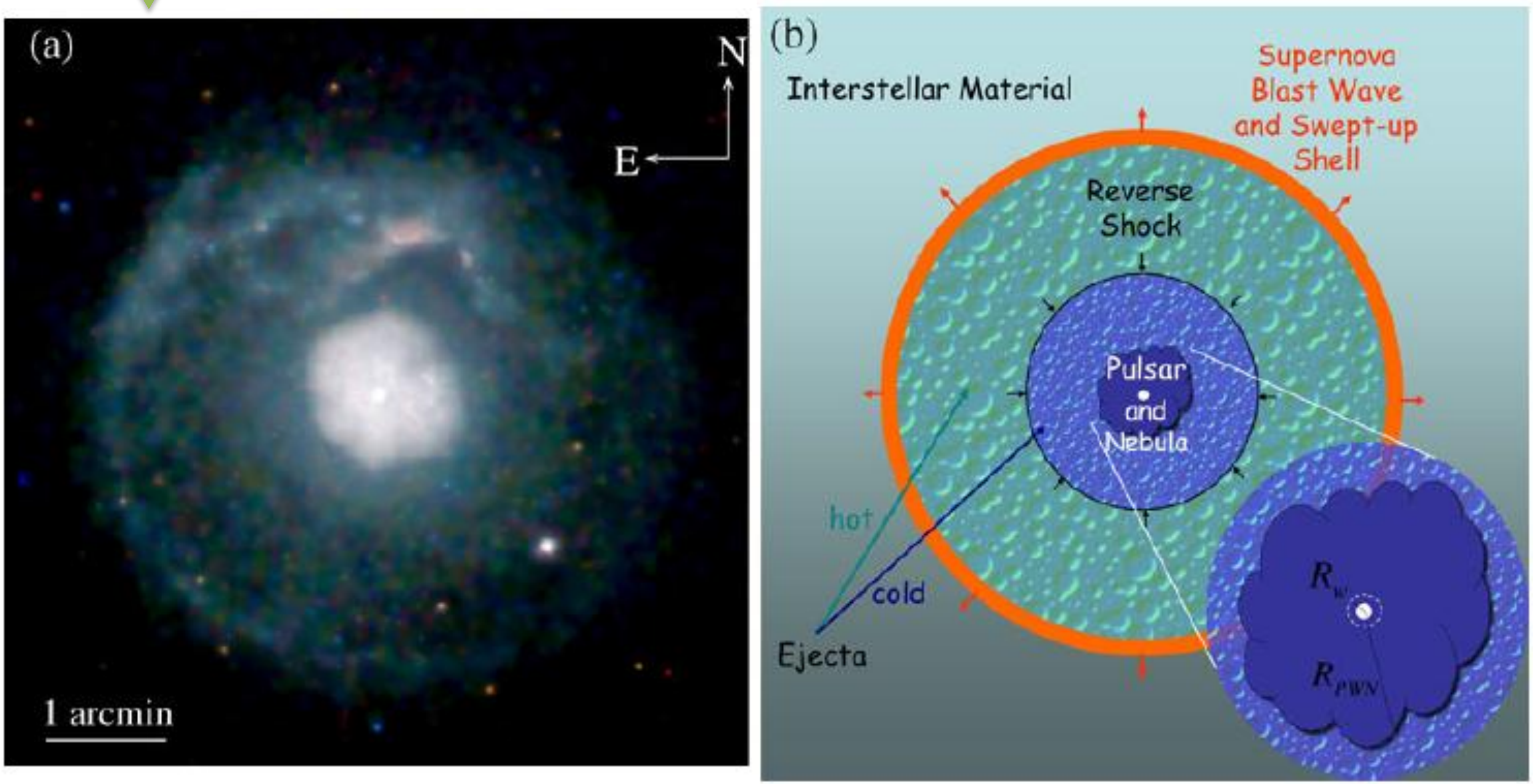
PWN Evolution

- The expansion of the PWN
- Interaction of the PWN with the surrounding SNR
- The motion of the pulsar powering the PWN

Deep *Chandra* image of the composite SNR G21.5-0.9

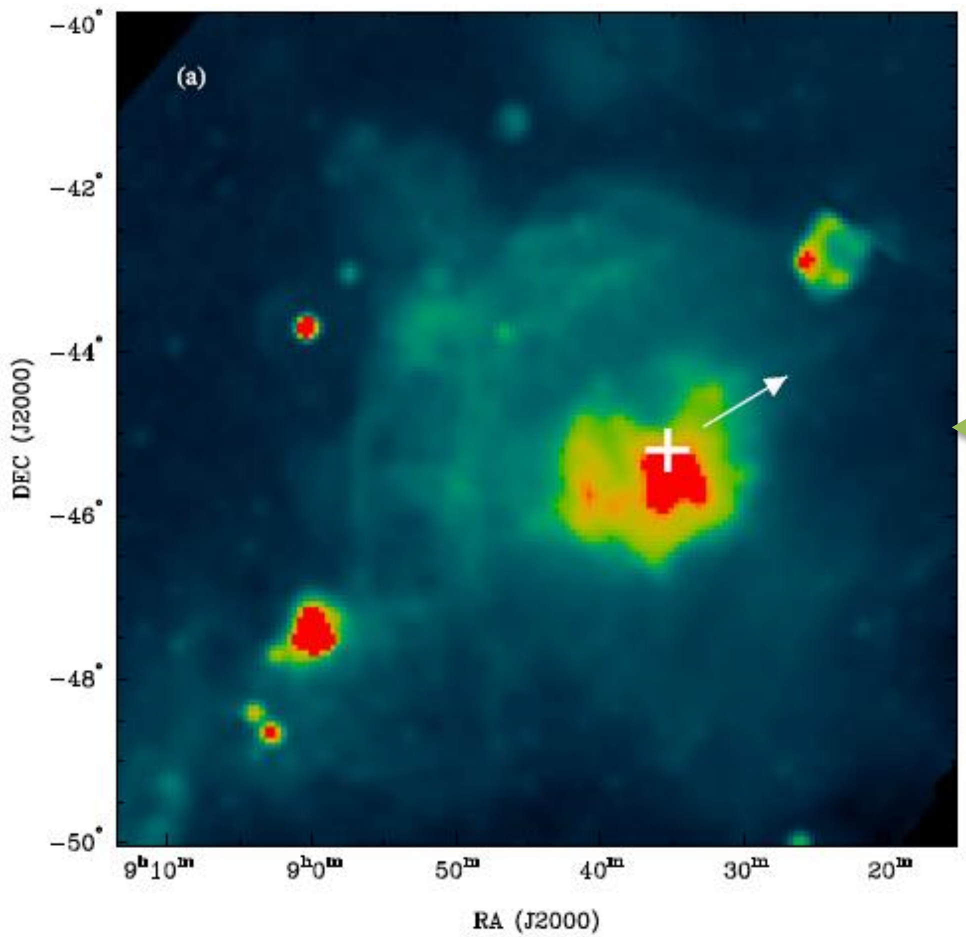
PWN Evolution

- The expansion of the PWN



PWN Evolution

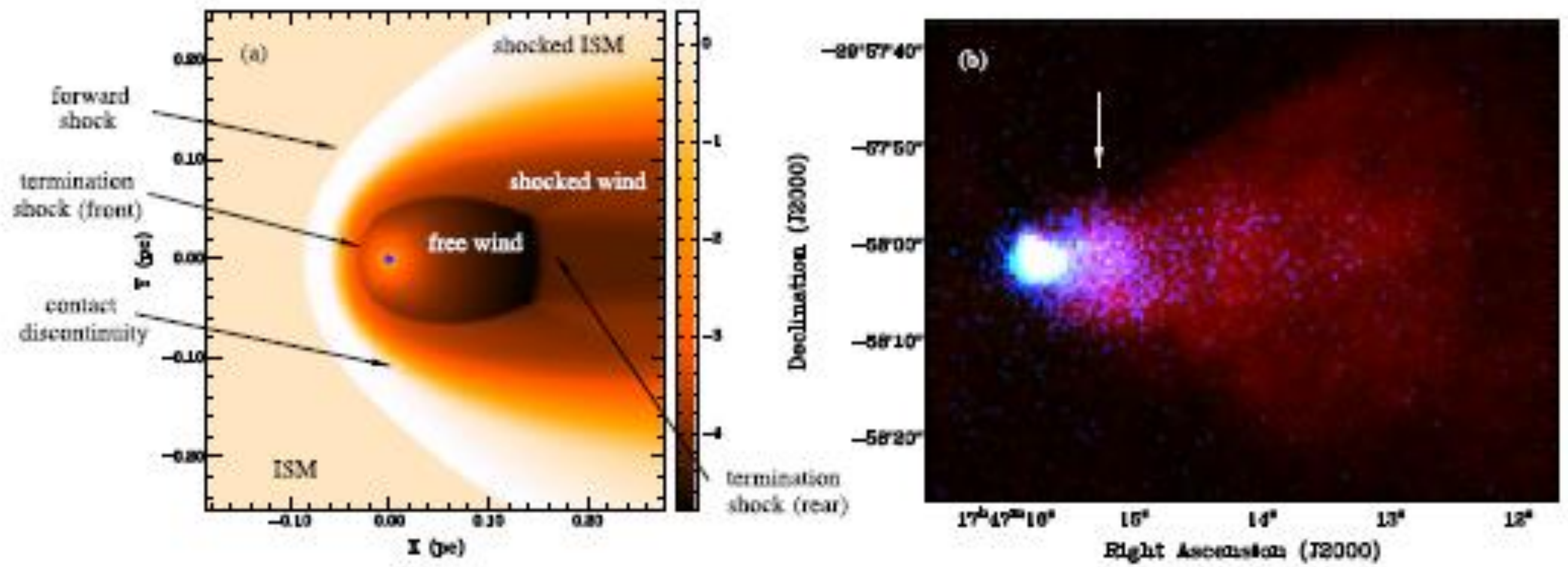
- Interaction of the PWN with the surrounding SNR



2.4 GHz Parkes image of the Vela supernova remnant. The *white cross indicates* the pulsar, and the *arrow its proper motion .*

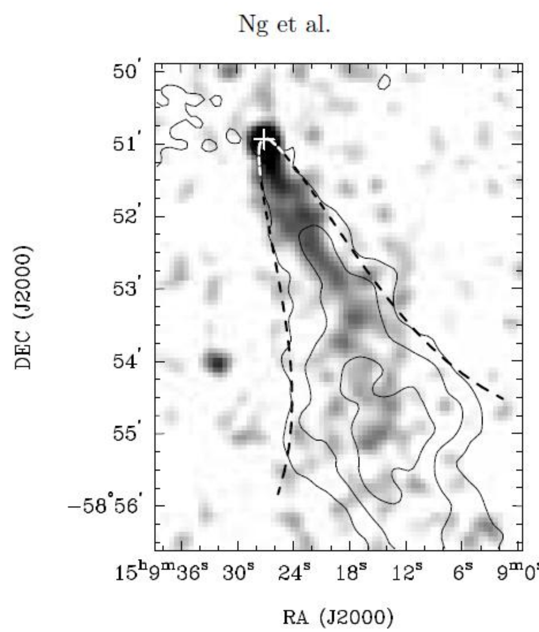
PWN Evolution

- The motion of the pulsar powering the PWN



Measuring PWN B-Fields

- Various techniques
- Different viewing angle
- The only limited observation of B-Fields is in pulsar bow shocks



I think after this talk…

- For PWN, maybe you know a little
- For B-Field in PWN….

- If you have any question, please ask next speaker, thank you!!!