X-rays from Supernova Remnants

Chandra
Sedov-Taylor Solution ($\gamma=7/5$)
X-rays from Supernova Remnants

Chandra
Cas A

Chandra

jets?

blast wave

Reverse shock

jets?
Cas A – Chandra – First Light Image

neutron star
Tycho’s SNR

Chandra

blast wave

Reverse shock
Tycho’s SNR

blast wave

Chandra

Reverse shock
SNR 0103-72.6 in SMC

- blast wave
- reverse shock oxygen

Chandra
X-ray Grating Spectrum (Chandra)

Oxygen 7 Res
Oxygen 8 Ly alpha
Neon 9 Res
Neon 10 Ly alpha
Magnesium 11 Res

Direct image, all energies

E0102–72

MIT/HETG
X-ray Grating Spectrum (Chandra)
X-ray Grating Spectrum (Chandra)
Radiative Supernova Remnants

Cygnus Loop

X-ray
Radiative Supernova Remnants

Cygnus Loop

Ha

The Cygnus Loop–Ha
Radiative Supernova Remnants

Cygnus Loop

Emission lines
Radiative Supernova Remnants

Cygnus Loop
Emission lines

Cygnus Loop
HST • WFPC2
Radio from Supernova Remnants

Crab Nebula (Plerion)  Cas A (Shell)
Radio from Pulsar, Pulsar Wind Nebula

Crab Pulsar at center
Synchrotron Em. From Blast Wave

Cas A
Radio from Supernova Remnants

Cas A
X-ray Synchrotron Emission

SNR 1006
X-ray Synchrotron Emission

SNR 1006
X-ray Synchrotron Emission

SNR 1006

- Supernova Remnant SN 1006
- Observed with the X-ray CCD Camera aboard the ASCA Satellite
High Energy Gamma-Rays

TeV gamma rays

Observed from Earth, Cherenkov light from air shower

H.E.S.S. (High Energy Stereoscopic System), also Victor Hess, discoverer of cosmic rays

Namibia, Africa
High Energy Gamma-Rays

H.E.S.S.
TeV Image of SNR1713.7-3946

H.E.S.S. (color)
(X-ray contours)
Power-law spectrum
Up to 10 TeV $\rightarrow$
e’s up to 100 TeV
Proves SNR accelerate cosmic rays

11/3/08