Spectacular Results from Recent Spitzer Observations of Cas A

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Outline

1. 24 micron image (Hines et al 2004) – jets
2. Light echoes (Krause et al 2004) – something funny
3. Our observations – IRAC, IRS
4. Once-shocked ejecta – composition, dynamics
5. Possible progenitor wind shell
6. Bipolar Ne-rich outflow – Doppler mapping, 3D structure
7. Spectral index – curvature, shock modification
8. Dust/Nucleosynthesis – J. Ennis poster
24 micron, MIPS

Lots of ISM structure
Most not related to Cas A

 Mostly dust emission
Lines of [FeII] and [OIV]
Look, a counterjet!

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Light Echoes

Apparent proper motions with v~c
Interstellar dust is heated by the explosion and by short duration (few weeks) episodic flares from the CCO, possibly beamed

Echoes are due to re-radiation, N and S “lobes” are in the plane of the sky and due to outburst in 1953
Momentarily quiescent SGR
But something’s funny here!

MIPS 24 micron

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Light Echoes

What about non-radial and apparent inward motions?

Krause acknowledged and ignored non-radial motions

Some echoes seem to require perfectly contrived ISM structures – filament to south

Radio knot to south used as evidence of outburst of relativistic particles from CCO moving at 0.6c – but not moving and where is counterpart to north?
Observations

Broadband observations in the 4 IRAC bands
3.6, 4.5, 5.7, 8 microns
1.2 arcsec spatial resolution

Spectral mapping with IRS
~5-40 microns, low resolution spectra
spatial resolution ~2 and ~6 arcsec
required over 1200 pointings for SL mapping
largest spectral mapping with Spitzer to date - CUBISM

Selected spectra of outlying blobs from MIPS

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Once-Shocked Ejecta

Combined line image of Ar, Ne, S, Si

Emission at center from Si, S, Fe – once-shocked (unshocked) ejecta

No associated dust component

Photo-ionized by X-ray and UV emission from twice-shocked ejecta (e. g. Hamilton et al 1997)

Two [SIII] lines to use as density indicator

Same lines observed in PWN of 0540-693 in LMC (Reynolds AAS)

Hidden PWN?

Stromgren Sphere around pulsar?

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Once-Shocked ejecta

Red=6000 km/s

Blue=-3000 km/s

Doppler structure of once-shocked ejecta may be used to determine explosion geometry

Current best guess – cavity – front and back edge

Doppler image using [ArIII], [SII]

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Progenitor Wind

Fesen 2001
Halpa+[NII]

location of outer ejecta to east
(Fesen, this conference)

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Progenitor Wind

Association of [SII] (left) with Halpa cloud (right)

Possible wind shell seen in [SIII], [SIII], [Nellli]
Ratios of these lines vary – temp/density

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Ne appears in most locations around remnant where other IR ejecta reside
To the north and south – Ne-rich emission (with O) – or perhaps merely absence of other ejecta – South is “hole” in the X-ray/optical

Possible association with outer ejecta “gaps”?

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**Bipolar Ne-rich Material**

- Perpendicular to jet
- Parallel to inferred CCO proper motion
- Doppler velocities opposite to X-ray Fe

**Synchrotron Spectrum**

IRAC Ch1 (3.6 micron) is dominated by synchrotron.

Spectral index measurements to radio image can be used to determine concave curvature and constrain shock modification models.

Preliminary measurements show spectral index flattening by 0.05 to 0.1 compared to radio values.
Dust/Nucleosynthesis

Dust composition changes, but temperature doesn't

Specific lines coupled to dust composition

Seeing different nucleosynthetic layers from progenitor

Peak near 21 μm from SiO₂ (am), Mg silicates, and FeO

Long-wavelength continuum dominated by Al₂O₃.

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