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DISCOVERY OF AN UNUSUAL OPTICAL TRANSIENT WITH THE *HUBBLE SPACE TELESCOPE* *

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SCP 06F6: A Carbon-rich Extragalactic Transient at Redshift $z = 0.14$

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Discovery of an Unusual Optical Transient with the Hubble Space Telescope

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Authors present observations of SCP 06F6, an unusual optical transient discovered during the Hubble Space Telescope Cluster Supernova Survey. The transient brightened over a period of ~100 days, reached a peak and then declined over a similar timescale. There is no host galaxy or progenitor star detected at the location of the transient.

Multiple spectra show five broad absorption bands between 4100 AA and 6500 AA and a mostly featureless continuum longward of 6500 AA. The shape of the lightcurve is inconsistent with microlensing. The transient's spectrum, in addition to being inconsistent with all known supernova types, is not matched to any spectrum in the Sloan Digital Sky Survey (SDSS) database.

Authors suggest that the transient may be one of a new class of supernova.

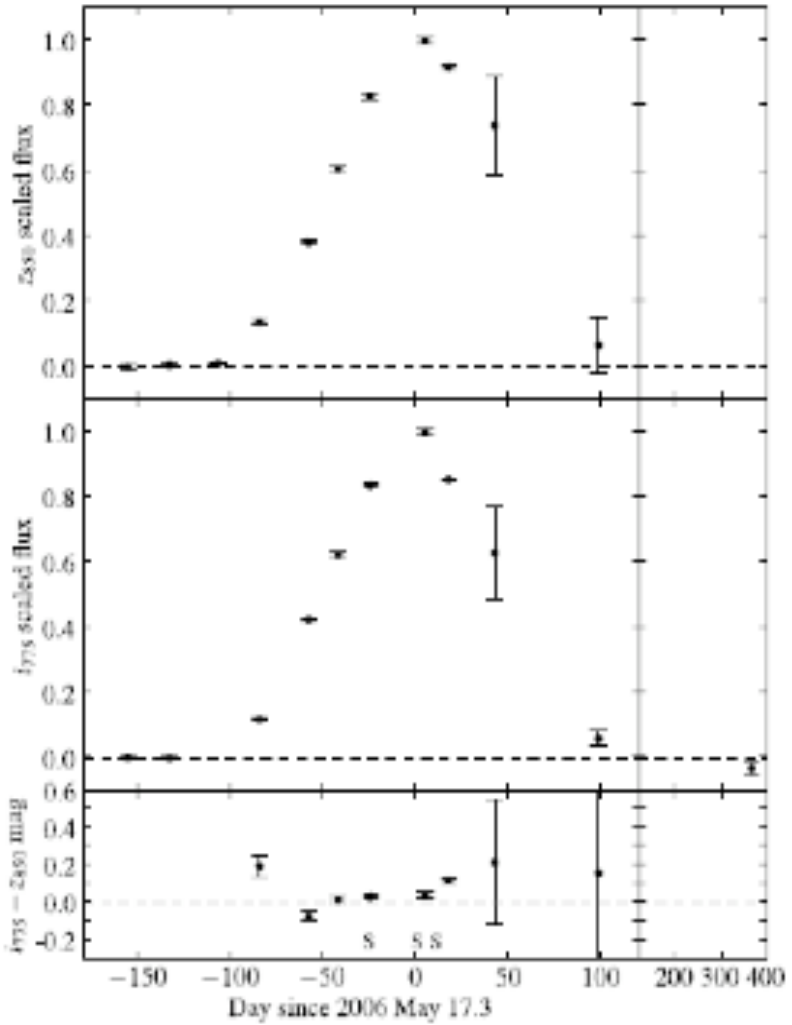


FIG. 2.— Flux lightcurve for z_{850} (*top panel*) and i_{775} (*middle panel*) scaled to maximum flux. The last three epochs (starting at +42 days) are Subaru FOCAS observations. *bottom panel*: $i_{775} - z_{850}$ color for epochs with significant detection in both bands. Though the color only varies ~0.2 magnitudes between the five best measured epochs, there is evidence for evolution. The spectral epochs are marked along the abscissa with an "S."

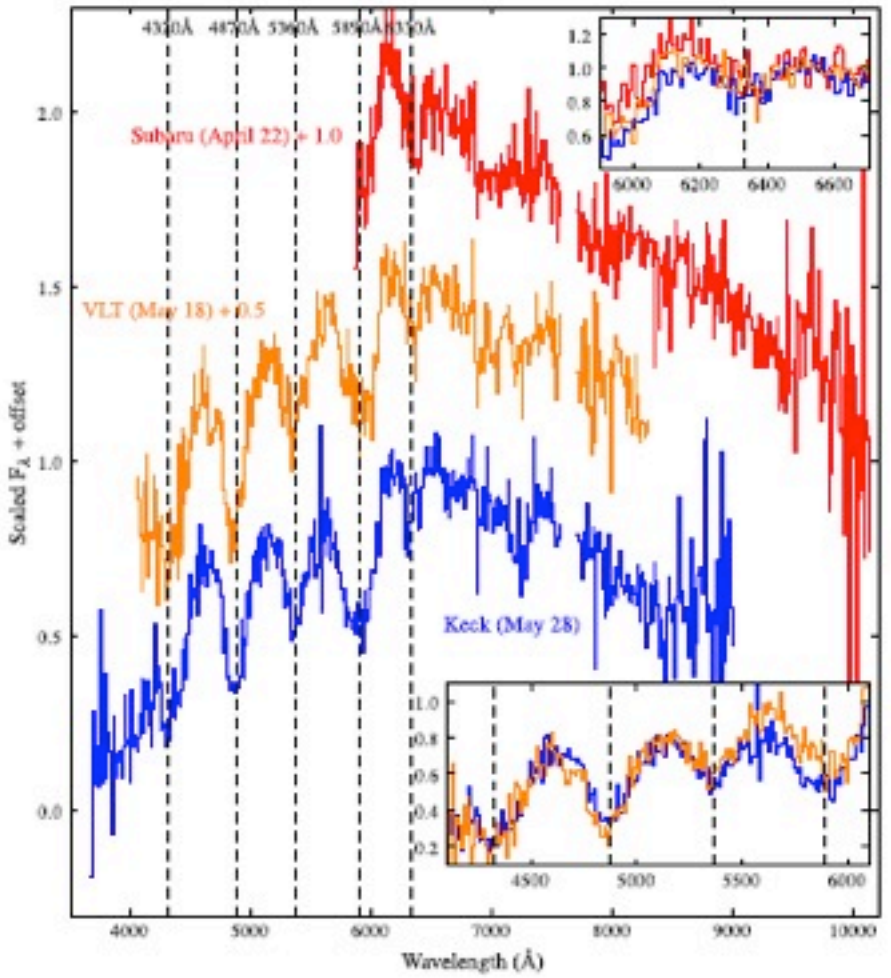
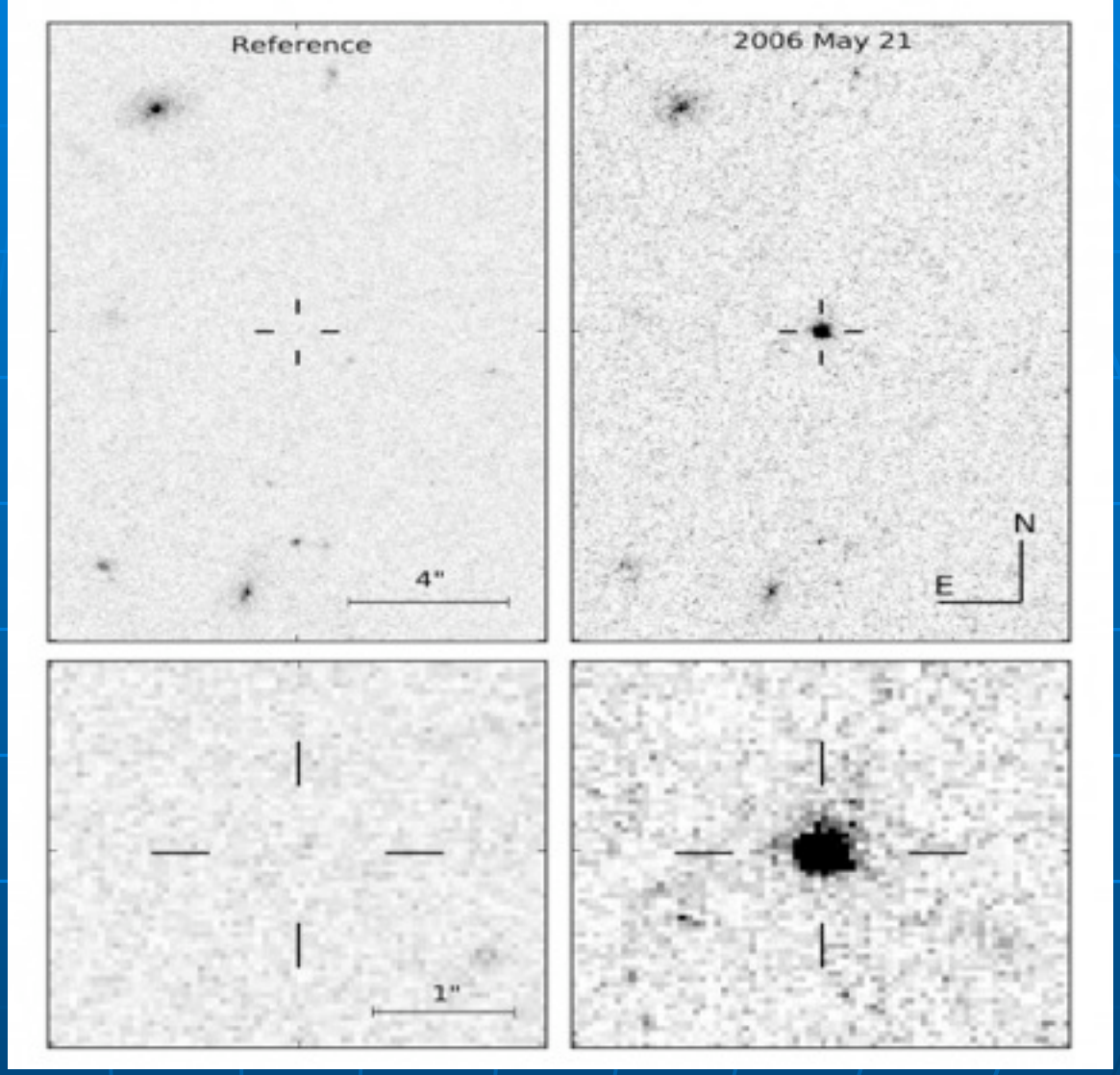


FIG. 3.— Spectra averaged in 10 Å bins. Vertical dotted lines indicate the approximate absorption band centroids. Spectra are normalized to match in the red continuum. Inset figures show regions where spectra differ. *Top Inset*: Overplot of all three spectra (no offset) in the range 5900 - 6700 Å, demonstrating apparent evolution of the flux at ~6150 Å relative to the red continuum. *Bottom Inset*: Overplot of VLT and Keck spectra (no offset) demonstrating apparent evolution at 4670 Å and of the absorption feature at 5890 Å.

First observed in 2006 SCP 06F6 flashed suddenly then faded from view over some 120 days. The event was so unusual, if fact, that astronomers had didn't know whether SCP 06F6 was located in our own galaxy or at the other end of the universe.



The sudden appearance of the transient "mystery object" SCP 06F6 in Hubble's field of view.

The strong X-ray emission may suggest the star was ripped apart by a black hole rather than exploding on its own. But …

"The lack of any obvious host galaxy for SCP 06F6 would imply either a very low black hole mass (if black holes do exist at the centre of dwarf irregular galaxy) or that the black hole has somehow been ejected from its host galaxy. While neither is impossible, this does make the case for disruption by a black hole somewhat contrived."

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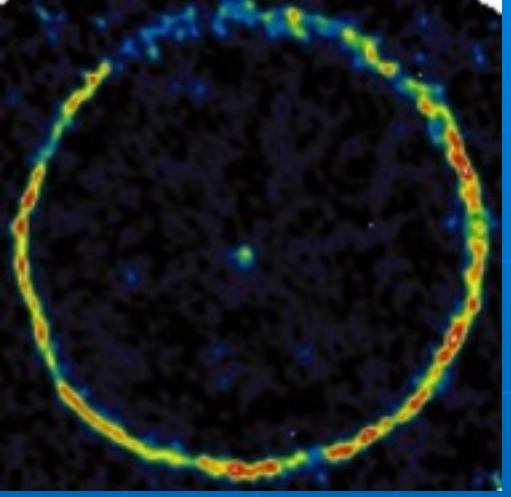
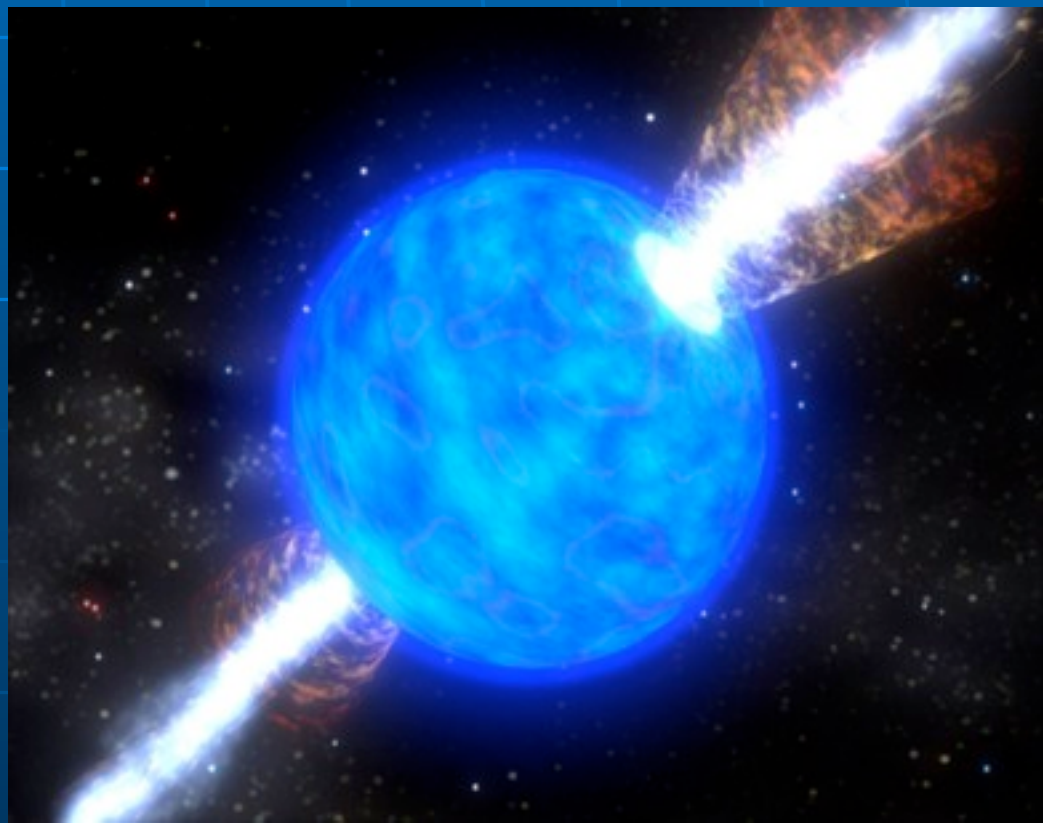
This Warwick team noticed the optical spectrum of SCP 06F6 looked a lot like light from cool stars with molecular carbon in their atmosphere. But to get a close spectral match with SCP 06F6, the team had to apply a redshift to the spectra of the carbon stars to correspond to a rapidly receding object some 2 billion light years away: Z=0.14. The large distance and the sudden appearance of SCP 06F6 suggest the object may be related to the sudden collapse of a carbon-rich star.



Carbon stars are similar to red giant stars. It's a late stage in the evolution of a star on its way to death. What makes a carbon star different from a regular red giant star is the fact that there's more carbon than oxygen in its atmosphere. That's a carbon star.

Carbon/Oxygen Stars Could Explode as Gamma Ray Bursts



Artist illustration of a gamma-ray burst. Image credit: NASA.

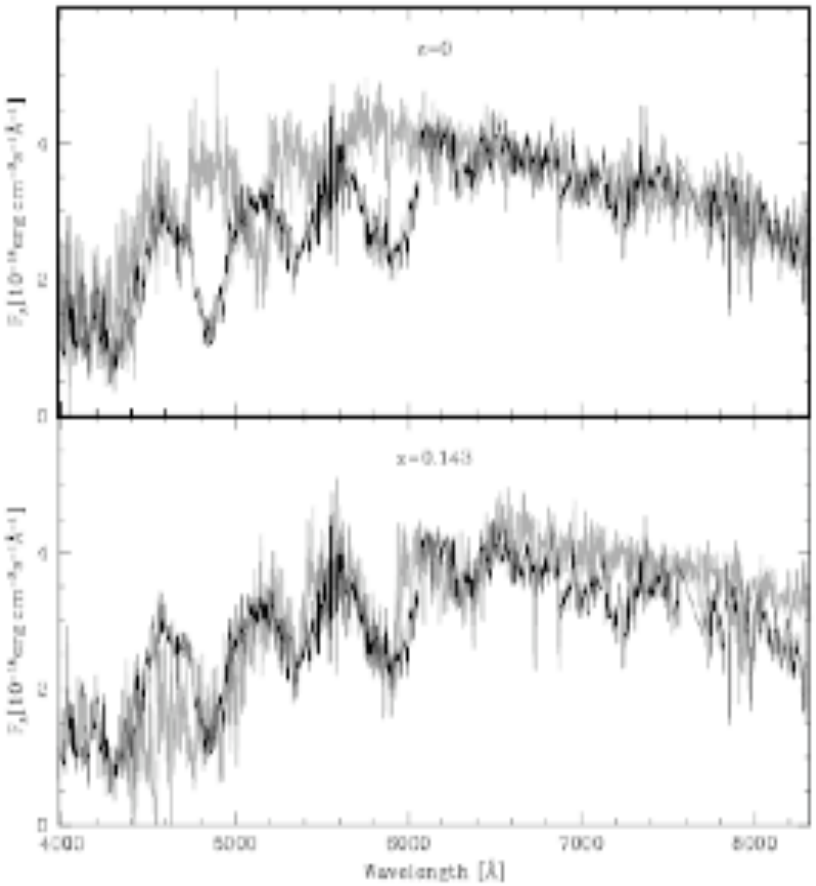


FIG. 1.— Top panel: the spectrum of SCP 06F6 (thin black line, co-added from the Keck and VLT data of Barbary et al. 2008) and the SDSS spectrum of the carbon star SDSS J001836.23-110138.5 (Downes et al. 2004). While the spectral energy distribution of the two spectra are similar, the positions of the C_2 Swan bands totally disagree. Bottom panel: same as before, but the spectrum of the carbon star has been redshifted to $z = 0.143$, which brings the positions of the Swan bands in agreement with the absorption troughs seen in SCP 06F6.

trum of SCP 06F6. DQ white dwarfs display a rich variety in the general morphology of the Swan bands, how-

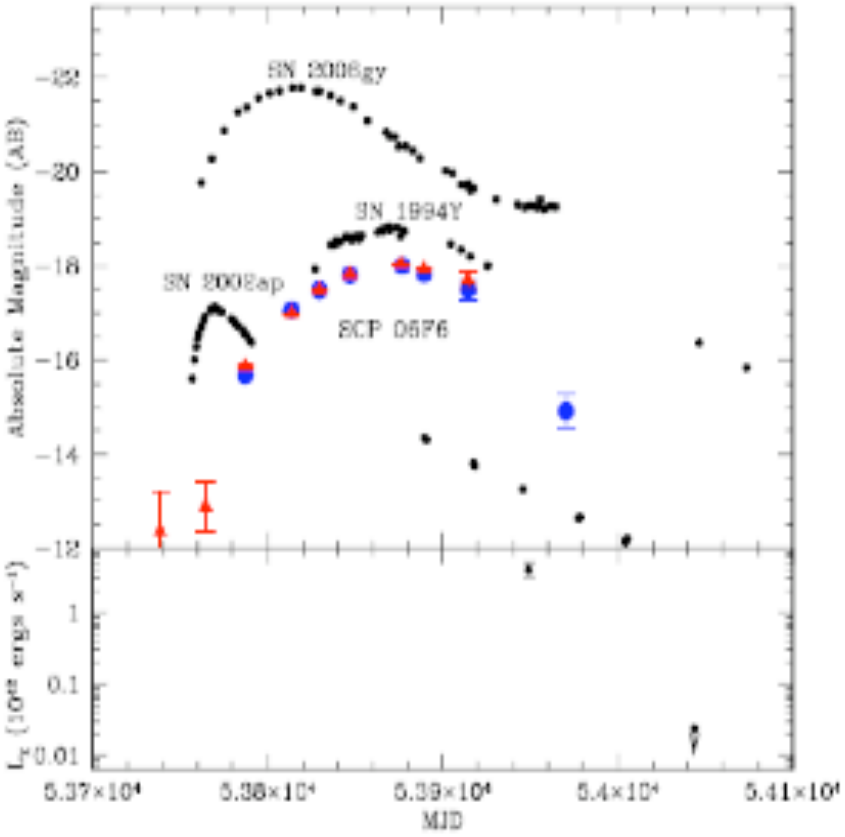


FIG. 2.— Top panel: the light curve of SCP 06F6, assuming its redshift to be $z = 0.14$ (blue circles i_{775}, red triangles z_{850}), it reaches a peak at both I and Z of $M_{I,Z} \sim -18$. Also shown for comparison are the light curves of SN 2002ap (Ic; Gal-Yam et al. 2002), SN 2006gy (IIn; Smith et al. 2007) and the slowly evolving SN 1994Y (IIn; Ho et al. 2001). The points have been plotted relative to the time frame of SCP 06F6 and thus the location of other SN points on the time axis is arbitary. Bottom panel: X-ray luminosities of SCP 06F6 implied by the *XMM-Newton* and *Chandra* observations. In addition, the object was not detected in a *Chandra* observation obtained ~ 1000 days before the onset of the optical outburst, consistent with an upper limit of $L_X \simeq 2 \times 10^{39}$ erg s^{-1}.

The discovered object SCP 06F6 is most likely related to the sudden death of a carbon-rich star, and the Warwick team believes that this object may be a new type of a totally new class of supernova.

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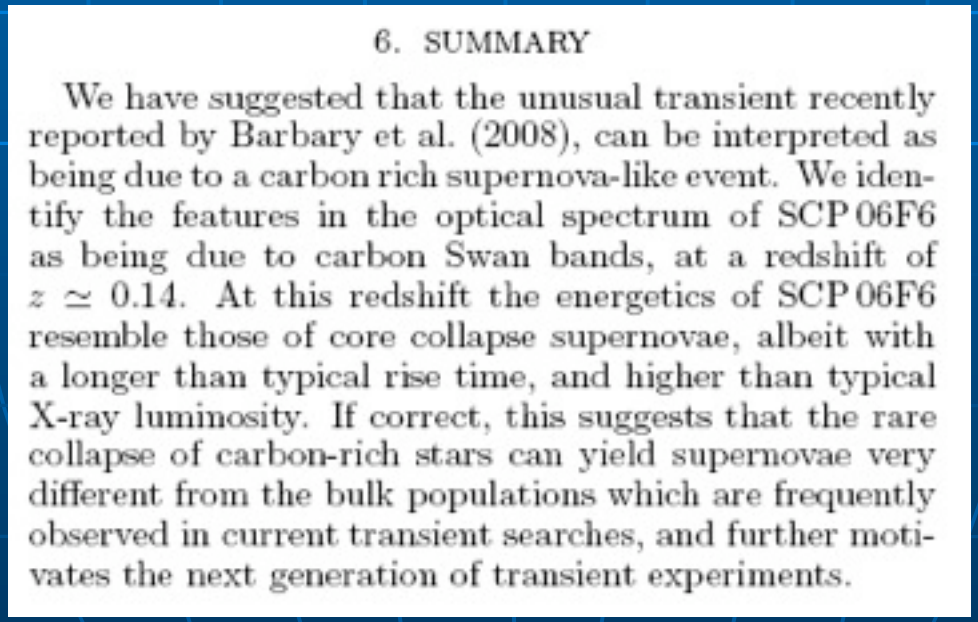

6. SUMMARY

We have suggested that the unusual transient recently reported by Barbary et al. (2008), can be interpreted as being due to a carbon rich supernova-like event. We identify the features in the optical spectrum of SCP 06F6 as being due to carbon Swan bands, at a redshift of $z \simeq 0.14$. At this redshift the energetics of SCP 06F6 resemble those of core collapse supernovae, albeit with a longer than typical rise time, and higher than typical X-ray luminosity. If correct, this suggests that the rare collapse of carbon-rich stars can yield supernovae very different from the bulk populations which are frequently observed in current transient searches, and further motivates the next generation of transient experiments.


THANK YOU