17083 - In search of the remnant of SN 2021fcg : detonation, deflagration or merger?

Cycle: 30, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	Institution	E-Mail
Viraj Karambelkar (PI) (Contact)	**California Institute of Technology**	**viraj@astro.caltech.edu**
Dr. Mansi Kasliwal (CoI)	California Institute of Technology	mansi@astro.caltech.edu
Dr. Kate Maguire (CoI) (ESA Member)	University of Dublin, Trinity College	kate.maguire@tcd.ie

VISITS

Visit	Targets used in Visit	Configurations used in Visit	Orbits Used	Last Orbit Planner Run	OP Current with Visit?
01	(1) SN2021FCG	WFC3/IR WFC3/UVIS	2	10-Oct-2022 15:00:15.0	yes

2 Total Orbits Used

ABSTRACT

Type Ia supernovae are thermonuclear explosions that result in the detonation of a white dwarf. Type Iax supernovae are a peculiar, less energetic sub-class of SNe Ia in which the white dwarf is believed to survive the explosion. This leaves behind a bound remnant, that is detectable at late-times when the supernova emission has faded. SN 2021fcg is a recently discovered unique member of this class. It is the lowest luminosity type Iax supernova as well as the least luminous thermonuclear explosion of any kind discovered to date. SN 2021fcg challenges the picture that SNe Iax originate in white dwarf deflagrations, and may hint towards a white dwarf merger origin. SN 2021fcg is also the nearest SN Iax discovered in the last decade, and provides an excellent opportunity to directly test the hypothesis that SNe Iax leave behind a bound remnant. Theoretical models predict that emission from the remnant will peak during HST Cycle 30. The supernova luminosity is also expected to be significantly lower than the

predicted remnant luminosity during Cycle 30, making it feasible to detect the bound remnant in this cycle. We propose to conduct late-time multi-band optical and near-infrared imaging of SN 2021fcg using HST WFC3 to search for the bound remnant and determine the remnant properties.

OBSERVING DESCRIPTION

The aim of this proposal is to use two HST orbits to image the location of SN 2021fcg using WFC3 UVIS F625W, F814W and IR F125W filters to search for a possible bound remnant. We plan to conduct dithered observations in these three filters, with exposure times of 1800 sec, 1700 sec and 2000 sec respectively. Using the WFC3 Exposure Time Calculator, we estimate depths of ~27 mag with S/N ~ 5 in each filter. These exposures together with all observing overheads amounts to 2 HST orbits.

As shown in Fig. 2 (Phase I proposal), this sensitivity will be sufficient to detect the SN remnant based on model predictions as well as previous observations of the similar SN 2008ha. In particular, the remnant will be detected in all three filters if it has a high envelope entropy, but F125W observations are crucial to detect it if the envelope entropy is low. As shown in Fig 3, the multi-band observations are necessary to accurately identify the nature of the detected source and determine the mass and entropy of the remnant. Both detections and non-detections will help us constrain these properties of the remnant.

We emphasize that Cycle 30 is an ideal time to search for the remnant of SN 2021fcg. First, on account of the extremely low luminosity and fast evolution rate of SN 2021fcg, the supernova emission is expected to fade below the remnant luminosities during Cycle 30 - merely 500 days since explosion. This is in stark contrast to brighter SNe Iax like SN2012Z, where significant supernova emission was seen even 3 years since explosion (McCully et al. 2022). Secondly, several theoretical models predict that the emission from the remnant should peak during Cycle 30 (Fig. 2). Throughout Cycle 30, SN 2021fcg is schedulable for several windows of ~2 week duration each. Therefore we do not place any constraints on the timing of HST observations.

We do not expect a reduced gyro mode to affect our observations significantly.

Visit	
Proposal 17083, Visit 01, implementation	Mon Oct 10 19:00:15 GMT 2022
Diagnostic Status: No Diagnostics	
Scientific Instruments: WFC3/IR, WFC3/UVIS	
Special Requirements: (none)	

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFC3-UVIS-DITHER-LINE-3PT Purpose=DITHER Number Of Points=3 Point Spacing=0.135 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false		(1)
(2)	Pattern Type=WFC3-IR-DITHER-BOX-MIN Purpose=DITHER Number Of Points=4 Point Spacing=0.572 Line Spacing=0.365	Coordinate Frame=POS-TARG Pattern Orientation=18.528 Angle Between Sides=74.653 Center Pattern=false		(5)

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	SN2021FCG	RA: 09 04 32.5700 (136.1357083d) Dec: +85 29 48.51 (85.49681d) Equinox: J2000	Redshift: 0.0054	V=27	Reference Frame: ICRS

Comments:
Category=EXT-STAR
Description=[SUPERNOVA, SUPERNOVA TYPE IA]

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) SN2021FCG	WFC3/UVIS, ACCUM, UVIS2-FIX	F625W	FLASH=2		Pattern 1, Exps 1-1 in Visit 01 (1)	600 Secs (1732 Secs) [==>(Pattern 1)] [==>(Pattern 2)] [==>532.0 Secs (Pattern 3)]	*[1]*
2		(1) SN2021FCG	WFC3/UVIS, ACCUM, UVIS2-FIX	F814W	FLASH=7.0	POS TARG 0.000,0.000		436 Secs (436 Secs) [==>]	*[1]*
3		(1) SN2021FCG	WFC3/UVIS, ACCUM, UVIS2-FIX	F814W	FLASH=7.0	POS TARG 0.092,0.098		435 Secs (435 Secs) [==>]	*[1]*
4		(1) SN2021FCG	WFC3/UVIS, ACCUM, UVIS2-FIX	F814W		POS TARG 0.185,0.197		769 Secs (769 Secs) [==>]	*[2]*
5	(1809201)	(1) SN2021FCG	WFC3/IR, MULTIACCUM, IR	F125W	NSAMP=11; SAMP-SEQ=STEP100		Pattern 2, Exps 5-5 in Visit 01 (2)	499.231969 Secs (1996.928 Secs) [==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	*[2]*

Orbit 1   Server Version: 20220630

Pointing Maneuver

Pointing Maneuver

Overhead

Pointing Maneuver

[↔] Exp. 2

Pointing Maneuver

Overhead

[↔] Exp. 3

Pointing Maneuver

Unused Orbital Visibility = 0

Occultation

Overhead

Overhead   Overhead

GS Acq [↔] Exp. 1   [↔] Exp. 1   [↔] Exp. 1

Orbit Structure

0   500   1000   1500   2000   2500   3000   3500   4000   4500   5000   5500   6000 sec

Orbit 2

Server Version: 20220630

Overhead
Pointing Maneuver

Pointing Maneuver

Pointing Maneuver

Pointing Maneuver

Occultation

GS Reacq

Reconfig

Reconfig

Exp. 4

Exp. 5

Exp. 5

Exp. 5

Exp. 5

Unused Orbital Visibility = 0

0   500   1000   1500   2000   2500   3000   3500   4000   4500   5000   5500   6000 sec

5