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APPLICATION FOR OBSERVING TIME

PERIOD: **102Z**

DDT

Important Notice:

1. Title

Category: **D–5**

Collapsars as the dominant contributor to the Galactic r-process abundances and the case of SN2017iuk.

2. Abstract / Total Time Requested

Total Amount of Time:

The pioneering event that signalled the beginning of multi-messenger astrophysics, GW170817/GRB170817, and the accompanying kilonova, AT2017gfo, have been claimed to be primary source of r-process material in the universe. However, some ultra-faint dwarf galaxies, like Reticulum II, is polluted early in its history by a rare, high-yield source. The time required for a binary star merger and low velocities of the natal kicks poses a problem for the suggestion that a binary neutron star merger is the source. A recent theoretical development suggests that the broad-lines Ic supernovae accompanying Gamma-Ray Bursts could be an additional source of the Galactic r-process. This process would work on a sufficiently rapid timescale, be associated especially with low-metallicity environments, and has suffient r-process yields to explain the inferred abundances. This theoretical model is directly testable in the recent supernovae, SN2017iuk. Only displaced by 163 Mpc from

3.

Run	Period	Instrument	Time	Month	Moon	Seeing	Sky	Mode	Type
A	102	HAWKI	1h	dec	n	0.8	PHO	s	
B	102	XSHOOTER	4h	dec	n	0.8	PHO	s	

4.

Number of nights/hours	Telescope(s)	Amount of time
a) already awarded to this project:		
b) still required to complete this project:		

5. Special remarks:

Take advantage of this box to provide any special remark using up to three lines

6. Principal Investigator: JSELSING

6a. Investigators:

All CoIs moved to the end of the document.

7. Description of the proposed programme

A – Scientific Rationale:

Since August 2017, the primary source of the r-process elements in the universe is believed to be formed in the merger of two neutron stars (ref), however see Côté et al. 2018 arXiv:1809.03525. This is based on the discovery of the first electromagnetic counterpart to a gravitational wave signal and the inferred r-process yields.

First localised in gravitational waves (Abbott et al. 2017, Phys. Rev. Lett. 119, 161101), the first optical counterpart to a binary neutron star merger was observed intensely in the entire electromagnetic spectrum (Abbott et al. 2017 ApJl 848, L12). From multi-wavelength imaging (Villar et al. 2017 ApJ 851 21) and spectroscopy covering the entire atmospheric transmission window (Smartt et al. 2017 Nat. 551 75, Pian et al. 2017 Nat. 551 67), a wealth of information is available in the primary emitting wavelength region, regarding the emission mechanisms, the composition of the emitting material, and the state of the gas contributing to the emission. Based on the comparison between the theoretical brightness as a function of ejecta mass and the observed luminosity of the kilonova an ejecta mass can be inferred. Assuming a composition of the ejecta and using an estimated neutron star merger rate as a function of time, it derived that neutron star mergers can be the primary source of r-process elements in the universe (refs).

However, determining the composition of the neutron star merger ejecta have so far proven difficult. The evidence for the ejecta being dominated by heavy r-process elements primarily stems from the qualitative agreement between the light curve evolution and spectroscopic evolution, as compared with theoretically synthesised models (Kasen et al. 2017 Nat 551, Tanaka et al. 2017). Attempts have been made to spectroscopically identify single elements (Smartt et al. 2017), where transitions from Cs I and Te I are suggested to cause observed spectroscopic absorption features. This identification is, however, still not confirmed and the suggested elements are not the cause of the observed absorption features (Watson et al. in submitted). One of the reasons for the absence of spectral identifications is the inadequacy of the atomic data of the heaviest elements (Barnes & Kasen 2013 ApJ 775 18), which causes the spectral modelling to rely on synthetic line-list, known to be discrepant compared to measured line strenghts (Waxman et al. 2017 arXiv:). As a consequence, the existence of r-process material in the neutron star merger of AT2017gfo must still be considered circumstantial, until direct spectroscopic identification of single elements are performed.

The initial powering of the emission in AT2017gfo is likely the radioactive decay of a large number of radioactive isotopes of the freshly synthesised material (Metzger 2017 LRR 20 3). As the energy from the radioactive decay is lost to radiation, the ejecta is left to cool and freely expand into the surrounding medium in a homologous way. As the expanding ejecta is encountering the interstellar medium, material is swept up and shock-heated by converting parts of the vast amount of kinetic energy locked away in the ejecta to be released as radiation. The X-ray generated in the shocks are reprocessed by high-opacity material and re-emitted at near-infrared wavelengths. The timescale for the powering depends on the ejected mass and the density and structure of the surrounding medium, where approximately the ejected mass needs to swept up, in order to significantly power the line emission. As enough material is swept up, a reverse shock is generated, moving inwards, heating the ejecta.

SN 1987A is an example of this re-brightening, where the SN ejecta encounters a pre-explosion shell that is ejected by the progenitor, prior to explosion.

B – Immediate Objective:

We here propose to observe the evolution of GRB171205A/SN2017iuk, $\sim$ 1 year after the explosion. Our primary science goal is to test the suggestion that GRB-SNe are a important source of r-process elements. Our secondary goal is the observations of the nebular phase of the most nearby GRB-SNe which will allow us to derive detailed constraints on the composition and kinematics of this, most rare subtype of supernovae.

The observations will consist of imaging in the near-infrared to put constraints on the light-curve brightness and spectroscopy to search for the presence of nebular lines. The appearance of the SN, this long after the initial explosion will allow us to put stringent constraints on the possible amount of the r-process element powering, which is one of the key observable predictions of the theoretical models.

The theoretically predicted spectroscopic appearance of the r-process powered transient associated with a long GRB is based on synthetic atomic data, and this appearance is therefore mainly meant to reproduce a qualitative between the theoretical spectra and the observed ones. The observed spectra will then serve as a benchmark going forward, also for the theoretical modelling of these types of transients.

SN2017iuk will be observable in December. Based on the extrapolated light curve from Siegel et al. 2018, it will be brightest in the near-infrared. The imaging will both allow us to put a strong limit on the amount of r-process material, and will provide a precise flux reference to recalibrate the spectra to. The prospect of directly detecting nebular emission from r-process elements ...

7. Description of the proposed programme and attachments

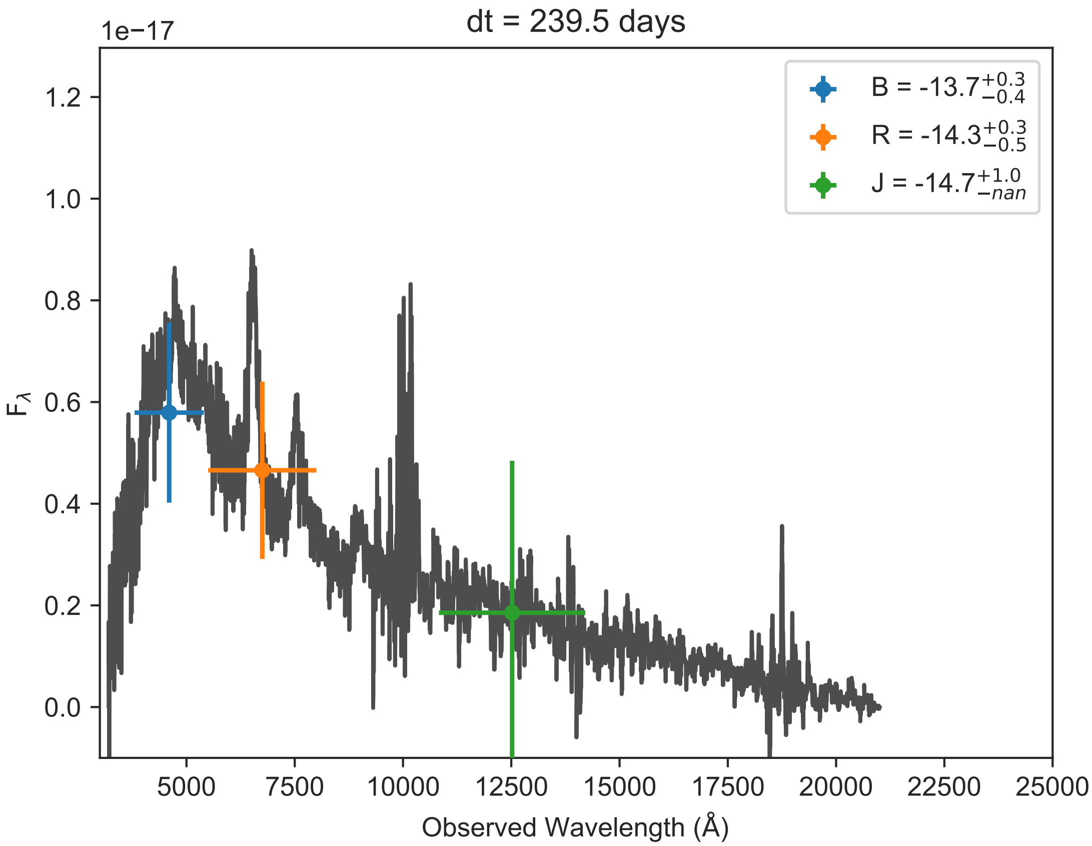

Fig. 1: A caption for your figure can be inserted here.

8. Justification of requested observing time and observing conditions

Lunar Phase Justification: Provide here a careful justification of the requested lunar phase.

Time Justification: (including seeing overhead) Provide here a careful justification of the requested number of nights or hours. ESO Exposure Time Calculators exist for all Paranal and La Silla instruments and are available at the following web address: http://www.eso.org/observing/etc. Links to exposure time calculators for APEX instrumentation can be found in Sections 7.1 and 7.2 in the Call for Proposals.

8a. Telescope Justification:

Justification for the use of the selected telescope (e.g., VLT, NTT, etc...) with respect to other available alternatives.

8b. DDT Justification:

Justification of the need for DDT.

8c. Calibration Request:

Special Calibration - Adopt a special calibration

9. Report on the use of ESO facilities during the last 2 years

Report on the use of the ESO facilities during the last 2 years (4 observing periods). Describe the status of the data obtained and the scientific output generated.

9a. ESO Archive - Are the data requested by this proposal in the ESO Archive (http://archive.eso.org)? If so, explain the need for new data.

Are the data requested in this proposal in the ESO Archive (http://archive.eso.org)? If yes, explain the need for new data.

9b. GTO/Public Survey Duplications:

Specify whether there is any duplication of targets/regions covered by ongoing GTO programmes. If so, please explain the need for the new data here. Details on the protected target/fields in these ongoing programmes can be found at:
GTO programmes: http://www.eso.org/sci/observing/teles-alloc/gto/index.html

10. Applicant's publications related to the subject of this application during the last 2 years

Name1 A., Name2 B., 2001, ApJ, 518, 567: Title of article1

Name3 A., Name4 B., 2002, A&A, 388, 17: Title of article2

Name5 A. et al., 2002, AJ, 118, 1567: Title of article3

11. List of targets proposed in this programme

Run	Target/Field	α(J2000)	δ(J2000)	ToT	Mag.	Diam.	Additional info	Reference star
A	NGC 253	00 47 33.1	-25 17 17.8	4	8		Seyfert gal.	
B	NGC 253	00 47 33.1	-25 17 17.8	4	8		Seyfert gal.	

Target Notes: This is a note about targets.

12. Scheduling requirements

This proposal involves time-critical observations, or observations to be performed at specific time intervals.

3. Unsuitable period(s) of time

Run	from	to	reason
A	15-jan-19	18-jan-19	Insert reason here
B	15-jan-19	18-jan-19	Insert reason here

12. Scheduling requirements contd...

4. Specific date(s) for time critical observations:

Run	**from**	**to**	**reason**
A	12-nov-18	14-nov-18	insert reason for time-critical observations.
B	12-nov-18	14-nov-18	insert reason for time-critical observations.

13. Instrument configuration

Period	Instrument	Run ID	Parameter	Value or list
102	XSHOOTER	B	300-2500nm	SLT
102	XSHOOTER	B	SLT	1.0,0.9,0.9JH
102	XSHOOTER	B	SLT	100k-1x2,100k-1x2 VIS,NDR
102	HAWKI	A	PRE-IMG	Y,J,H,Ks
102	HAWKI	A	IMG	Y,J,H,Ks

6b. Investigators:

	...moved from first page.	
D.	Watson	14042
D.	Malesani	14042
J.	Bolmer	1261
P.	Schady	1496