ICRANet press release "*On the Supernova breakout in the BdHN GRB 190114C*", March 2019

In March 2019, ICRANet has prepared an important press release on the Supernova breakout in the BdHN GRB 190114C, which will be sent out for publication. On January 14, 2019, GRB 190114C was announced by the team of the Swift satellite (GCN 23688). Its distance (redshift z=0.42) was determined a few hours later by the Nordic Optical Telescope located at the Canary Islands – Spain (GCN 23695). Soon after we recognized that this source was a BdHN I, ICRANet sent the GCN 23715 (see full text below) anticipating the possibility of the appearance of an associated Supernova. The Supernova was indeed detected at the exactly predicted time, as reported by A. Melandri et al. on 19 March 2019 (GCN 23983). We herby illusrate the relevance of this ephocal observations, by evidencing the universal role of the Supernova mass both in BdHN I and BdHN II.

One of the largest multimessenger Observational effort in the history of Astrophysics

The detection and follow-up of GRB 190114C has been made possible thanks to a worldwide effort of many satellites and telescopes with a very strong participation of Italy through the International satellites Swift (NASA-DOE mission with the participation of Italy and the UK) and Fermi (NASA-DOE mission with the participation of ASI, INFN and INAF), and with the Italian satellite AGILE. Specifically, this GRB has been observed in the X-ray and gamma-ray energy domain by the satellites Swift, Fermi, AGILE, INTEGRAL, Insight-HXMT/HE (a Chinese X-ray satellite of IHEP, Tsinghua University-China), Konus-Wind (Russia); also, in the highest gamma-ray energy domain by Fermi-LAT (USA and Italy) and the MAGIC telescopes, located at the Roque de los Muchachos Observatory, Canary Islands – Spain (with the collaboration of institutions in Germany, Armenia, Bulgaria, Croatia, Finland, Italy, Poland, Spain and Switzerland); finally in the optical domain by the telescopes MASTER-IAC (Russia), Pan-STARRS (Haleakala Observatory, Hawaii - USA), the Nordic Optical Telescope-NOT, located at Canary Islands – Spain (owned by the Nordic Optical Telescope Scientific Association, and funded by Denmark, Finland, Iceland, Norway and Sweden), MPG+GROND (La Silla Observatory, Chilean Atacama Desert-Chile), GCT+OSIRIS (Canary Islands - Spain), Osservatorio Astronomico S. Di Giacomo (Agerola - Italy), VLT+FORS2, the NTT+EFOSC2 and the REM+ROS2 at the European Southern Observatory - ESO (Chile), the TNG+DOLORES (INAF), the LBT+MODS2 (INAF) located at Mount Graham (Arizona - USA), the WHT+ACAM located at the Roque de los Muchachos Observatory (Canary Islands - Spain), McDonald Observatory (USA), SNU Observatory (Seoul - South Korea), AZT-33IK located at the Sayan Observatory (Russia), LSGT at the Siding Spring Observatory (Australia), GROWTH-India telescope at the Indian Astronomical Observatory (India), KMTnet in the South African Astronomical Observatory (South Africa), UKIRT, RC-1000 of the CHILESCOPE Observatory (Chile), HCT located at the Indian astronomical observatory (India), COATLI and the Harold Johnson Telescope at Osservatorio Astronomico Nacional on the Sierra de San Pedro Martir (Mexico), RTT150 at the TUBITAK National Observatory (Turkey); in the radio band domain by the Karl G. Jansky Very large Array (VLA), the Atacama LargeMillimeter/Submillimeter Array (ALMA), the Australia Telescope Compact Array (ATCA), the Sardinia Radio Telescope (INAF), the MeerKAT radio telescope (South Africa) and the Giant Meterwave Radio Telescope – GMRT (India).

What is a BdHN?

ICRANet has been following the study of GRBs since the earliest discovery time to the latest observations by a theoretical analysis, which has led, among others, to the classification of all GRBs in nine different subclasses. Binary driven Hypernovae (BdHN) are the most numerous of such subclass. Their progenitor is a binary system composed of carbon-oxygen (CO) core and a magnetized neutron star (NS) companion in a very compact orbit of binary period of the order of minutes. The CO core collapses at its center forming a new NS (νNS), but the external layers are ejected in form of a Supernova (SN) explosion, see figure enclosed. The SN ejecta produces a massive and rapid accretion process onto the NS companion leading to its gravitational collapse forming a black hole (BH). Meanwhile, the Supernova ejecta continues to expand but still matter remain around of both the νNS and the BH. The background magnetic field (B) collapse, together with the rotation of the BH, triggers the "Wald" process by which an electric field is induced. This

E-field explains both the ultra relativistic prompt emission phase (UPE) in the gamma-rays through the transparency of the self-accelerating electron-positron pair plasma created by quantum electrodynamic process of vacuum breakdown, and the GeV emission through synchrotron emission of accelerated protons in the B-field. The interaction of the νNS pulsar emission with the SN ejecta explains the X-ray afterglow. Finally, after about 15 days, the optical emission of the SN produced by the energy release of the decay of Nickel, is observed.

What is exceptional in GRB 190114C

Truly exceptional is that all phases of the BdHN starting from the onset of the SN break-out, to the accretion process, to the moment of formation of the Black Hole, to the observation of the GeV emission and afterglow to the final identification of the optical Supernova have become observable with enormous precision in this most unique source.

GCN CIRCULAR

NUMBER: 23715
SUBJECT: GRB 190114C: A type 1 BdHN with TeV emission
DATE: 19/01/15 15:29:54 GMT
FROM: Remo Rufinni at ICRA ruffini@icra.it

R. Ruffini, R. Moradi, Y. Aimuratov, U. Barres de Almeida, C. L. Bianco, Y. C. Chen, C. Cherubini, S. Filippi, D. M. Fuksman, M. Karlica, Liang Li, D. Primorac, J.A. Rueda, N. Sahakyan, Y. Wang, S.S. Xue on behalf of the ICRANet team, report:

GRB 190114C with T90=116 s (50-300 keV), Epeak = 998.6 +/- 11.9 keV, isotropic energy release in gamma-rays Eiso = 3 E53 erg, and the isotropic peak luminosity Liso = 1 E53 erg/s (R. Hamburg et al., CGN 23707) presents the typical characteristics of type I binary-driven hypernova (BdHN) (Y. Wang et al., submitted to Astrophysical Journal arXiv:1811.05433v2). The most significant ever Fermi-LAT GeV emission (D. Kocevski et al., GCN 23709) with test statistic value TS>2500 implies that this GRB is seen from the normal to the orbital plane of the progenitor binary system composed of a carbon-oxygen core and a neutron star companion (R. Ruffini et al., submitted to Astrophysical Journal arXiv:1803.05476). The TeV emission (R. Mirzoyan et al., GCN 23701), a first in GRBs, has been recently predicted, as originating from the Wald solution, within the new inner engine approach of the long GRBs recently introduced in Ruffini et al (submitted to Physical Review Letter: arXiv:1811.01839) and Ruffini et al (submitted to Astrophysical Journal: arXiv:1812.00354). Most interesting this system being at z=0.4245 (A. J. Castro-Tirado et al., GCN 23708), can give a strong support to our BdHN approach by Observing a Supernova. Using the averaged appearance time of the SNe associated to GRBs (Cano et al., 2016), and considering the redshift z=0.42 (J. Selsing et al., GCN 23695, A. J. Castro-Tirado et al., GCN 23708), a bright optical signal will peak at 18.8 +/- 3.7 days after the trigger (February 2nd 2019, uncertainty from January 30th 2019 to February 6th 2019) at the location of RA 54.510 and DEC -26.939, with an uncertainty 3 arcmin (J.D. Gropp et al., GCN 23688). The follow-up Observations, especially the optical bands for the SN, are recommended.

GCN CIRCULAR

NUMBER: 23983
SUBJECT: GRB 190114C: photometric detection of a SN component
DATE: 19/03/20 21:25:17 GMT
FROM: Andrea Melandri at INAF-OAB <andrea.melandri@brera.inaf.it>

A. Melandri (INAF-OAB), L. Izzo (HETH/IAA-CSIC), P. D'Avanzo (INAF-OAB), D. Malesani (DAWN/NBI and DARK/NBI), M. Della Valle (INAF-OAC), E. Pian (INAF-OAS), N. R. Tanvir (U. of Leicester), F. Ragosta (U. Federico II/OAC), F. Olivares (MAS/U. de Chile), R. Carini (INAF-OAR), E. Palazzi (INAF-OAS), S. Piranomonte (INAF-OAR), P. Jonker (SRON), A. Rossi (INAF-OAS), D. A. Kann (HETH/IAA-CSIC), D. Hartmann (Clemson U.), C. Inserra (Cardiff), E. Kankare (Turku), K. Maguire (QUB), S. J. Smartt (QUB), O. Yaron (Weizmann), D. R. Young (QUB), I. Manulis (Weizmann) on behalf of a larger collaboration

We report the discovery of the supernova associated with the gamma-ray burst GRB 190114C (Gropp et al., GCN 23688) at z=0.42 (Selsing et al., GCN 23695; Castro-Tirado et al., GCN 23708; Kann et al., GCN 23710). An observational campaign lasting about 50 days has been carried out with the VLT+FORS2, the NTT+EFOSC2 and the REM+ROS2 at the European Southern Observatory (Chile), the TNG+DOLORES, the LBT+MODS2 located at Mount Graham (Arizona), and the WHT+ACAM located at the Roque de los Muchachos Observatory (Canary Islands). These observations show, at about 15 days after the burst, an apparent flattening of the afterglow light curves, in the i and z filters, in excess of the host galaxy flux, as measured in our latest epochs. This is the consistent with the emergence of a SN associated with GRB 190114C, as observed in several previous events.
By modelling the overall light curve between 0.01 and 15 days after the burst trigger (including also data from GCN circulars) with a broken power-law (afterglow contribution) + constant (host galaxy contribution), the residual fluxes in the observed i and z bands show a peak of brightness of ~23.9 and ~23.5 mag (AB), respectively. With these values we derive an estimate for the rest frame visual absolute magnitude of the SN associated with GRB 190114C of about -18 mag. This value is about 1 mag fainter than SN 1998bw (Patat et al. 2001, ApJ, 555, 900). However, the two SNe could have a comparable brightness considering the significant extinction, yet to be quantified, suffered by this event (see e.g. Kann et al., GCN 23710).
We caution that the reported values for the SN peak brightness strongly depend on the modeling of the temporal behavior of the overall light curve. Further photometric and spectroscopic analysis is ongoing.
We thank the VLT, TNG, LBT and WHT staffs for executing these observations. Part of these data have been obtained under the extended Public ESO Spectroscopic Survey for Transient Objects (ePESSTO; see Smartt et al. 2015, A&A, 579, 40; http://www.pessto.org <http://www.pessto.org/>).

The many episodes of a Binary driven Hypernova (BdHN)