2014

A program for optical observations of advanced LIGO early triggers in the southern hemisphere

Matthew Benacquista
The University of Texas Rio Grande Valley, matthew.benacquista@utrgv.edu

Chris Belczynski
University of Warsaw

Martin Beroiz
The University of Texas Rio Grande Valley

Maria Branchesi
University of Urbino Carlo Bo

Carlos Colazo
Universidad Nacional de Córdoba

See next page for additional authors

Authors
Matthew Benacquista, Chris Belczynski, Martin Beroiz, Maria Branchesi, Carlos Colazo, Mario Contreras Diaz, Mancheno Dominguez, Diego Garcia Lambas, Shengnan Liang, Lucas Macri, Tania Peñuela, Beatriz Sanchez, Marcos Schneiter, and Cristina V. Torres

A program for optical observations of advanced LIGO early triggers in the southern hemisphere

M. Benacquista[1], C. Belczynski[1,2], M. Branchesi[3] M. Beroiz[1], C. Colazo[5], M.C. Díaz[1], M. Dominguez[5], D. Garcia Lambas[5], S. Liang[1], L. Macri[4], T. Peñuela[1,6], B. Sanchez[5], M. Schneiter[5], C.V. Torres[1]

1 Center for Gravitational Wave Astronomy, The University of Texas at Brownsville, 2 Warsaw University Observatory, 3 Università di Urbino/INFN Sezione di Firenze 4, Mitchell Institute for Fundamental Physics and Astronomy, Texas A&M University, 5 Instituto de Astronomía Teórica y Experimental y Observatorio Astronómico de Córdoba, Universidad Nacional de Córdoba, 6 Ludwig Maximilian University

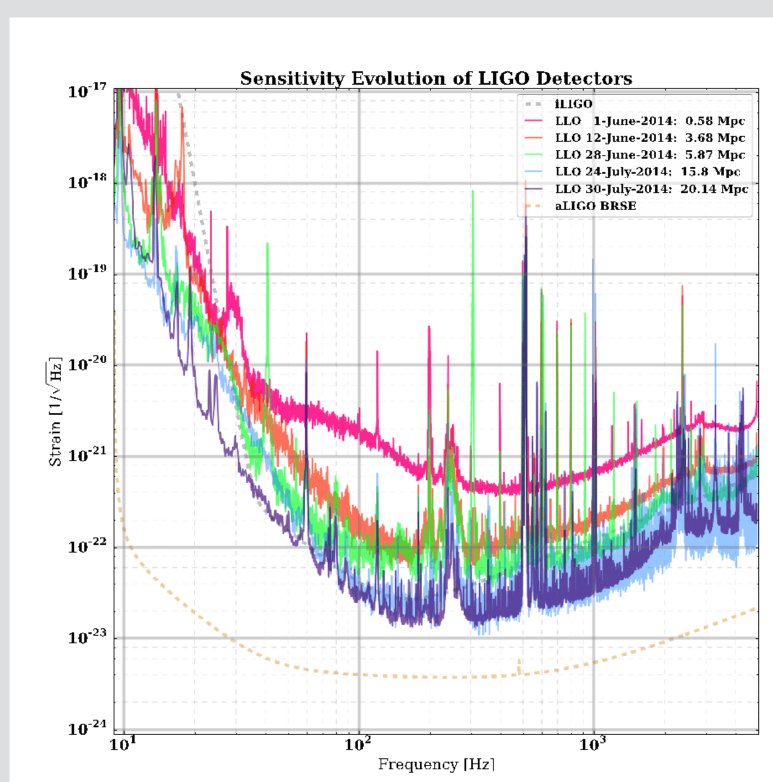
Advanced LIGO and Gravitational Wave Detections

Binary Neutron Stars (NS-NS) and Neutron Star Black Hole (NS-BH) mergers are among the most promising candidates for producing gravitational-wave (GW) signals visible out to 300 Mpc with the advanced generation of the LIGO (http://www.ligo.org) and Virgo detectors (http://www.ego-gw.it). If a short gamma-ray burst (SGRB) is produced and beamed towards Earth, satellites like Swift or Fermi will detect a prompt high-energy electromagnetic (EM) emission that would most likely be a counterpart to a GW event[1] which lasts seconds. A longer-lived emission, may be detected out to a larger angle in X-ray, UV, optical, and radio bands. Furthermore, the mergers are expected to produce an isotropic optical/IR emission, called kilonova[2].

The Advanced LIGO detectors will start their first scientific run sometime near the end of the summer of 2015.

In July 2014 the detector at the Livingston Laboratory (LLO) achieved its longest lock, lasting three hours at a sensitivity that would detect GWs from coalescing neutron stars at a distance of more than 20 Mpc. This makes LLO the most sensitive gravitational wave detector ever put into operation.

The LIGO VIRGO Scientific Collaboration (LVC) has made public a plausible scenario for the operation of the LIGO-Virgo network over the next decade[3].



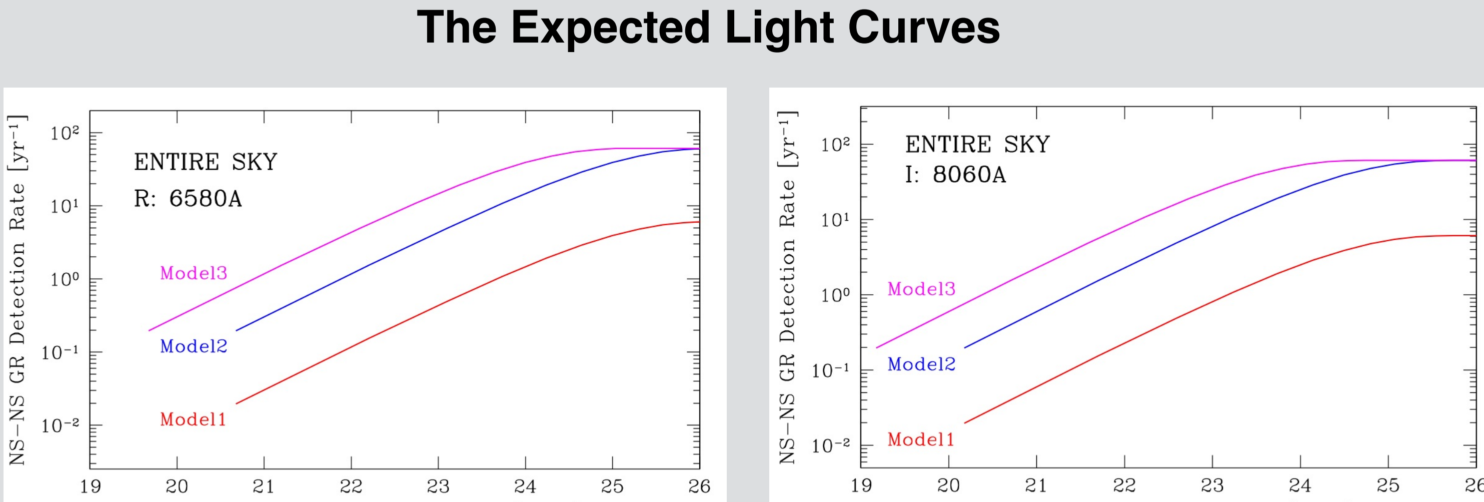
The L1 DARM displacement spectrum from end July 2014 (source: https://www.advancedligo.mit.edu)

One of the first three observing periods are scheduled in 2015 (3 month duration; with two LIGO detectors at early advanced sensitivity while Virgo is still in commissioning with a chance to join the run).

A call for proposals to sign a Memorandum of Understanding (MoU) with LVC to promptly obtain alerts to EM follow-up GW candidate events was opened on December 16, 2013 with deadline February 16, 2014. The TOROS (Transient Optical Robotic Observatory of the South) signed a Memorandum of Understanding with LVC to participate in the electromagnetic follow-up program.

TOROS (http://toros.phys.utb.edu) is a collaboration formed by scientists from The University of Texas at Brownsville, the Universidad Nacional de Cordoba, Texas A&M University and other universities in Europe who have partnered to develop an astronomical optical observatory in the Southern hemisphere dedicated to follow up triggers from aLIGO and aVIRGO.

The Expected Light Curves



The three models depicted in the plots above represent three possible event rates estimated from population synthesis predictions.

The electromagnetic signals associated with NS-NS merger events expected to be observed by aLIGO and AdVirgo will be faint and most likely with light curves as the ones observed recently for GRB 130603B[4].

The plots near the bottom of the left column are estimations of NS-NS mergers events per year detectable as kilonovae at given magnitude in the visual and R band[5]. The TOROS site will be located in Co Macón, at latitude 24.61 South and longitude 67.32 West, at an altitude of 4,650 meters in the province of Salta, Argentina. The site was first surveyed by ESO as one of the candidates for the E-ELT telescope. Average seeing was measured as an annual average of 0.79 and a median of 0.55 arcsecs[6].

The long term goal of the TOROS collaboration is to build a facility capable of surveying ~50 square degrees per hour and provide a SNR=10 detection of a V=22 (I=21) mag transient in that time.

The TORITOS Project

The TOROS telescope will not be operational before 2016. In consequence the TOROS collaboration will operate a smaller instrument at Co Macon to participate in the 2015 aLIGO first scientific run. The instrument, called TORITOS, consists in a 0.40 m Schmidt Cassegrain telescope with an Apogee Alta U16 CCD which has a 0.5 deg x 0.5 deg FOV with a 0.45 arcsec/pixel resolution. TORITOS will be capable of operating robotically during 2014-2015. Although quite limited in the sky area coverage, it can survey up to 12 square degrees per night and detect events with a SNR=10 of a V=20 mag transient (under median observing conditions).

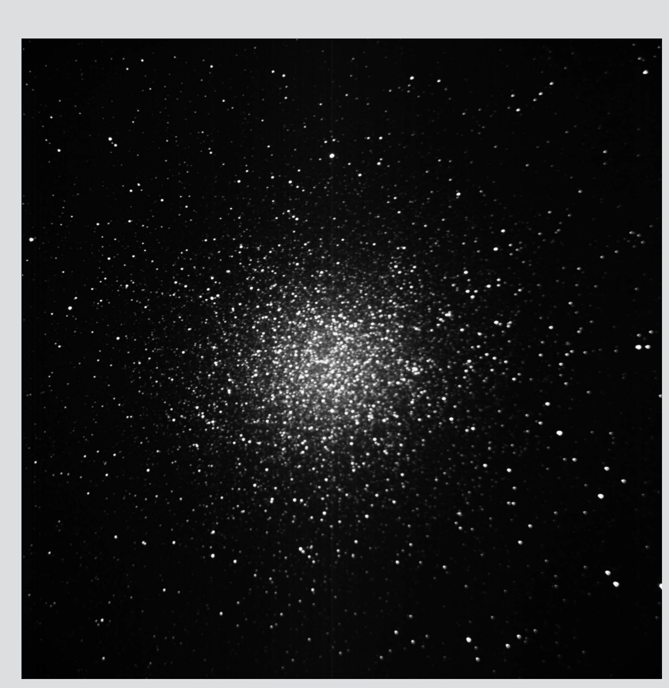
The telescope will have four basic modes of operation: (1) follow up of gravitational-wave triggers; (2) follow up of gamma-ray burst triggers from Fermi, Swift, and other satellites; (3) baseline imaging of the entire surveyable area; and (4) search for short-duration transient events, variable sources and moving objects within the DES and VISTA-VIKING fields.

Additionally, the collaboration plans to execute its own photometric and spectroscopic followup of relevant transients. The photometric followup will make use of the ABRAS (http://abras.oac.uncor.edu/en) 1.1- m telescope expected to see first light early 2015, also to be located at Macón, and the Bosque Alegre 1.5-m telescope from OAC in Córdoba (http://www.oac.uncor.edu/M2SM4.html). The spectroscopic followup will be conducted using target-of-opportunity time on larger instruments.

TORITOS building in the forefront. The ABRAS dome in the background

Carlos Colazo and Matias Schneiter

TORITOS First Light



NGC 5139 w/ Apogee AU10

The calibration and first operation of the instrument occurred in April 2014.

Its first light on April 18, 2014 was an image of the Omega Centauri cluster which is shown on the left.

References

1. E. Nakar, Phys. Rep. 442, 166 (2007).
2. Li L., Paczynski B., 1998, ApJ, 507, L59. Kulkarni S. R., 2005, preprint, arXiv:astro-ph/0510256, Metzger B. D., Berger E., 2012, ApJ, 746, 48
3. LVC collaboration, Prospects for Localization of Gravitational Wave Transients by the Advanced LIGO and Advanced Virgo Observatories, arXiv:1304.0670.
4. Tanvir et al, A 'kilonova' associated with the short-duration c-ray burst GRB 130603B, Nature, 500, 547 (2013), Berger et al, Smoking gun or smoldering embers? http://arxiv.org/abs/1306.3960 (2013).
5. Belczynski, Optical/IR Counterparts of GW Signals (NS-NS and BH-NS mergers), First TOROS workshop, http://toros.phys.utb.edu/TOROS/First_TOROS_Workshop_Program_files/talkBelcz.pdf, Belczynski et al. 2008 ApJS 174, 223, Dominik et al. 2012 ApJ 759, 52. See also: D. Kasen, R. Fernandez and B. Metzger, preprint arXiv:1411.3726.
6. V. Renzi, R. Vrech, D. Ferreiro, D. García Lambas, M. Solinas, H. Muriel, J. Viramonte, M. Sarazin and P. Recabarren, "Caracterización Astronómica del Sitio Macón, en la Provincia de Salta" (in Spanish). Argentine Astronomical Association annual conference, September 2009, La Plata, Argentina.