INTEGRAL upper limits on gamma-ray emission associated with the gravitational wave event GW150914


Using observations of the INTEnational Gamma-Ray Astrophysics Laboratory (INTEGRAL), we put upper limits on the gamma-ray and hard X-ray prompt emission associated with the gravitational wave event GW150914, discovered by the LIGO/Virgo collaboration. The omni-directional view of the INTEGRAL/SPI-ACS has allowed us to constrain the fraction of energy emitted in the hard X-ray electromagnetic component for the full high-probability sky region of LIGO trigger. Our upper limits on the hard X-ray fluence at the time of the event range from $F_{\gamma} = 2 \times 10^{-8}$ erg cm$^{-2}$ to $F_{\gamma} = 10^{-6}$ erg cm$^{-2}$ in the 75 keV - 2 MeV energy range for typical spectral models. Our results constrain the ratio of the energy promptly released in gamma-rays in the direction of the observer to the gravitational wave energy $E_{\gamma}/E_{GW} < 10^{-6}$.


The INTEGRAL collaboration has signed a memorandum of understanding with the LIGO-Virgo collaboration to follow-up the GW triggers with its X-ray and gamma-ray instruments. SPI-ACS was operating nominally at the time of the LIGO trigger on 2015-09-14 at 09:50:45 UTC, yielding an uninterrupted count rate from 33 hours before to 19 hours after the event. The background was stable and low, with a rate of $\sim 7 \times 10^4$ counts/s. The noise at every time scale can be described by a Gaussian process (Savchenko et al. 2012, A&A, 541A, 122S).

We investigated the light curve at $-30$ to $+30$ s from the trigger time on 5 time scales from 0.05 to 10 s, the expected accretion time scales in the compact binary coalescence (Lee & Ramirez-Ruiz 2007, NJPh, 9, 17L). We do not detect any obvious signal coincident with the GW trigger.

Response simulation and verification

The response of SPI-ACS is affected by the surrounding satellite structure and the other INTEGRAL instruments. We developed a GEANT3 Monte-Carlo model based on the INTEGRAL mass model (based on Sturner et al. 2003, A&A, 411L, 81S). We verified that the response is valid for the bursts detected simultaneously by SPI-ACS and other detectors to an accuracy better than 20%.

A dedicated intercalibration study between INTEGRAL/SPI-ACS, Fermi/GBM, and Konus-Wind is ongoing.

Upper limits

SPI-ACS covered about 95% of the GW150914 localization with near-optimal sensitivity, and the 5% with a sensitivity factor 3 lower (darker area). The limit depends, on the incident spectrum (see the range of the limits in the Table).

INTEGRAL/IBIS constrains fluence in 570 keV - 1200 keV energy range at a level of $2.5 \times 10^{-7}$ erg cm$^{-2}$ and $6.5 \times 10^{-7}$ erg cm$^{-2}$ assuming durations of 1 s and 10 s, respectively.

Implications and conclusions

Using INTEGRAL/SPI-ACS we set an upper limit on the ratio of the energy directly released in gamma-rays in the direction of the observer to the gravitational wave energy $E_{\gamma}/E_{GW} < 10^{-6}$ ($E_{\gamma}$ in 75-2000 keV). This result is compatible with the expectation of negligible electromagnetic counterpart to binary BH coalescence.

Our upper limit is in disagreement with the Fermi/GBM detection of a possible EM counterpart 0.4 s after the GW (Connaughton et al 2016, arXiv:1602.03920) for all their allowed fit parameters. In the plot, we show an estimate of the expected SPI-ACS signal if the GBM event were of a cosmic origin.