Simulating Off-Axis Short Gamma-Ray Burst Afterglows To Inform Electromagnetic Follow-Up to Future Gravitational Wave Events

Garcia, Leon (School: Corvallis High School)

Gamma-ray bursts (GRBs) are astrophysical explosions that release more energy in a few seconds than the sun releases in its entire 10 billion year lifetime. This project studies short-duration GRBs, ultrarelativistic explosions formed by neutron star mergers accompanied by an optical-near-infrared explosion (“kilonova”), the only observed source of heavy element (e.g., gold, platinum) production. Since 2005, the afterglows of GRBs have been observed across the electromagnetic spectrum. These “on-axis” bursts require that the merger’s jet be pointed towards Earth. Gravitational wave (GW) detectors are able to detect these mergers without observing the jet. Currently, behavior of “off-axis” burst afterglows is relatively unknown, even though the majority of GW-detected mergers will have off-axis afterglows. Here, I derive physical properties (including kinetic energy and circumburst density) from observations of on-axis short GRB afterglows. Using these derived properties, I simulate light curve models for off-axis bursts’ afterglow emission across the electromagnetic spectrum and explore their observability in the context of current telescopes. I find that off-axis bursts at distances of 464.3 Mpc are optimally observed at radio wavelengths 1-100 days after the burst is initially detected using gravitational waves with a 1-hour exposure using the Very Large Array (VLA). The optimal time to observe the flux shifts further and further after the burst occurs as the observing angle is further off-axis.

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