Title:	Implications of the Lag-Luminosity Relationship for Unified Gamma-Ray Burst Paradigms
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Abstract

Spectral lags (τ_{lag}) are deduced using a cross-correlation methodology for 1429 long (T_{90}>2 s) BATSE gamma-ray bursts (GRBs) with peak flux F_p>0.25 photons cm^{-2} s^{-1}, near to the BATSE trigger threshold. The lags are modeled as a power-law function of peak flux with limit parameters for the lag extrema. Lag model errors are assigned via a novel decimation procedure, drawing from the observed lag distribution with F_p and τ_{lag} as governing parameters. The model parameters were adjusted within a five-dimensional grid to achieve best agreement with the observed distribution in the F_p-τ_{lag} plane. Assuming a two-branch lag-luminosity relationship, the lags are self-consistently corrected for cosmological effects to yield distributions in luminosity, distance, and redshift. The results have several consequences for GRB populations and for unified gamma-ray/afterglow scenarios that would account for afterglow break times and gamma-ray spectral evolution in terms of jet opening angle, viewing angle, or a profiled jet with variable Lorentz factor. A component of the burst sample is identified-those with few, wide pulses, lags of a few tenths to several seconds, and soft spectra-whose logN-logF_p distribution approximates a -3/2 power law, suggesting homogeneity and relatively nearby sources. The proportion of long-lag bursts increases from negligible among bright BATSE bursts to ~50% at trigger threshold. Bursts with very long lags, ~1-2s<τ_{lag}<10 s, show a tendency to concentrate near the supergalactic plane with a quadrupole moment of roughly -0.10+/-0.04. GRB 980425 (SN 1998bw) is a member of this subsample of ~90 bursts with estimated distances less than 100 Mpc. The frequency of the observed ultralow-luminosity bursts is ~1/4 that of Type Ib/c supernovae (SNe Ib/c) within the same volume. The model lags predict a power-law scaling relation for the ultralow-luminosity GRBs, $dN_{sen}/dL \sim L^{-1}$, flatter than expected ($dN_{sen}/dL \sim L^{1/6}$) if viewing angle with respect to the jet axis alone governed perceived luminosity. For high-luminosity bursts, the modeling yields $dN_{vol}/dL \sim L^{-1.8}$, similar to expectations for viewing angle scenarios ($dN_{vol}/dL \sim L^{-2}$) however, if luminosity decreases off-axis, $L \sim \theta^{-\lambda}_{view}$ (λ>0), then overproduction of low-luminosity bursts results. Thus, the relativistic kinematic factor as the dominant component for the dynamic range in GRB luminosities is not favored. The variable beaming fraction scenario, with constant luminosity across the jet cone, can fit the high-luminosity bursts with a fairly flat distribution in jet cone solid angle, $dN(\Omega_{jet})/d\Omega_{jet}\sim\Omega^{-0.2}_{jet}$ for the ultralow-luminosity bursts a distribution that increases is required, $dN(\Omega_{jet})/d\Omega_{jet}\sim\Omega^{0.5}_{jet}$. Jets with variable luminosity profiles viewed at a range of angles can also reproduce the observed luminosity distributions, such that $L\sim\theta^{-2.5}_{view}$ and $L\sim\theta^{-1.3}_{view}$ for high- and ultralow-luminosity regimes, respectively. Approximately 1/300 of the universal SN Ib/c population would be required to produce GRBs at cosmological distances, with a rate of 1×10^{6} to a few times 10^{6} yr^{-1}. The modeled redshift distribution for GRBs peaks at z~10, with large uncertainty.