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The origin and non-universality of the earthquake inter-event time distribution

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Understanding the form and origin of the earthquake inter-event time distribution is vital for both the advancement of seismic hazard assessment models and the development of physically-based models of earthquake dynamics. Many authors have modelled regional earthquake inter-event times using a gamma distribution, whereby data collapse occurs under a simple rescaling of the data from different regions or time periods. We use earthquake data and simulations to present a new understanding of the form of the earthquake inter-event time distribution as essentially bimodal, and a physically-motivated explanation for its origin in terms of the interaction of separate aftershock sequences within the earthquake time series. Our insight into the origin of the bimodality is through stochastic simulations of the Epidemic-Type Aftershock Sequences (ETAS) model, a point process model based on well-known empirical laws of seismicity, in which we are able to keep track of the triggering "family" structure in the catalogue unlike with real seismicity. We explain the variation of the distribution shape with region size and show that it is not universal under rescaling by the mean event rate. The power-law segment in the gamma distribution usually used to model inter-earthquake times arises under some conditions as a crossover between the two peaks; the previous results supporting universality can be explained by strong data selection criteria in the form of a requirement for short-term stationarity in the event rate.