Fitting Poisson Process Model to Incomplete Data: Aerodynamic Study of a Methanol Spray Flame

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ABSTRACT

Incomplete data can arise in many different ways. Each requires a different statistical method to analyze it. Well-known types of incomplete data are the so-called censored data encountered in clinical trials and random truncated luminosity data in astronomy. These are in the study domain of the survival analysis in statistics. In engineering, incomplete data often occur due to the presence of dead time in recording instruments. In this presentation we analyze such a data set collected by the Phase Doppler Interferometry (PDI). PDI is a non-intrusive technique for obtaining information about spray characteristics in aerosol science, including liquid fuel spray in combustion, spray coatings, and pesticide dispensing. An important characteristic is the velocity distribution of the droplets in a spray. PDI can record the velocity of individual droplets in a spray. But it will miss some of the droplets due to a recurring presence of dead time. Proper correction for dead time is necessary otherwise the statistical inference will be biased. The incompleteness of the PDI recordings results in a multi-modal interarrival time distribution of droplets (not an exponential distribution). Yet it is shown that the a homogeneous Poisson process fits well our experimental spray data. We estimate the spray diffusion rate (Poisson intensity) with a correction for dead time under various conditions. The interplay between model fitting and incomplete data is emphasized. The asymptotic distribution of the estimates is derived from a strictly stationary process. Simulation produced a good agreement between our estimates (in the presence of dead time) and the MLE obtained without dead time. Experimental data of methanol spray flame from the National Institute of Standards and Technology will be used for illustration.