R11b A formulation of the Confusion Problems in the Source Count Statistics

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The source confusion is a long-standing problem of the astronomical history, going back to the works of Eddington. In its early stage, this issue has been developed and formulated mainly by radio astronomers in relation to the so-called $P(D)$ analysis (Scheuer 1957; Hewish 1961; Bennett 1962; Murdoch et al. 1973; Condon 1974). The $P(D)$ analysis is known to be a powerful tool to explore the source counts fainter than the confusion limits, and to estimate cosmological evolution of the source population. This analysis has been applied and further developed by X-ray (e.g., Barcons 1992 and references therein) and infrared astronomy (e.g., Franceschini et al. 1989; Bertin et al. 1997 and references therein). Now confusion problem becomes also important in submillimeter cosmology and high-precision astrometric missions (cf. Hogg 2000).

Fundamental assumption of the formulation is that the sources are distributed homogeneously on the sky. However, this assumption is obviously not realistic in many applications, e.g., stars in the Galaxy, or galaxies in the Universe. Qualitatively, clustering increases the confusion effect to some extent, but it is not an easy task to formulate the effect of clustering in the confusion problem. Up to now, only Barcons (1992) has made attempt to tackle the riddle and given solutions to a few very simplified cases. In this work, by making extensive use of the methods developed in the counts-in-cells analysis, we show the general analytic formula for the confusion problems with arbitrary distribution and correlation functions. With this formula, we can obtain the confusion noise level for the sources with some prescribed correlation structure.