The Effect of Unresolved Contaminant Stars on the Astrometry of Photometric Catalogues

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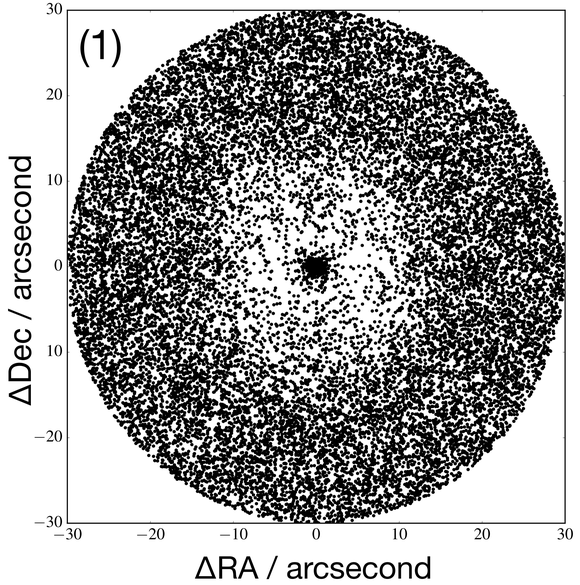
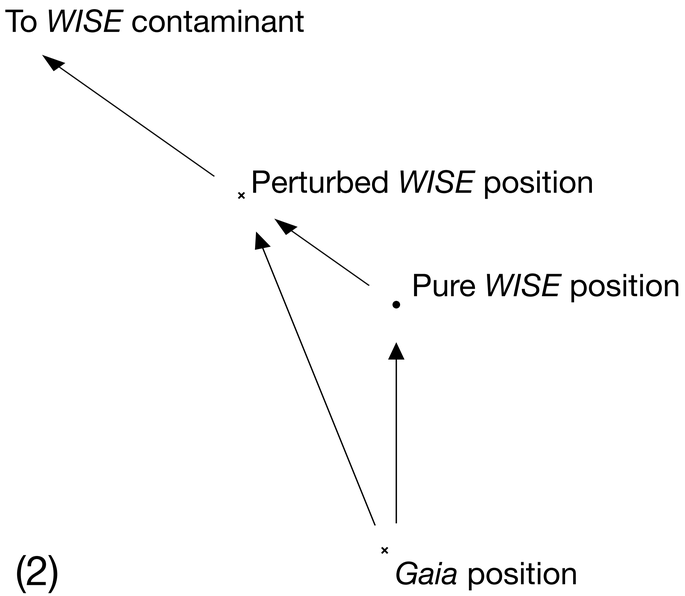
Bright stars crowd out nearby faint sources in photometric catalogues. An example, for *WISE* stars near to a subset of *Gaia* sources, is shown in Figure (1). The density of neighbouring stars far from the sources is high, with counterpart detections in the nearest few arcseconds. There also is a reduced density of sources too far from the *Gaia* sources to be counterpart detections, and thus must be missing neighbouring detections.

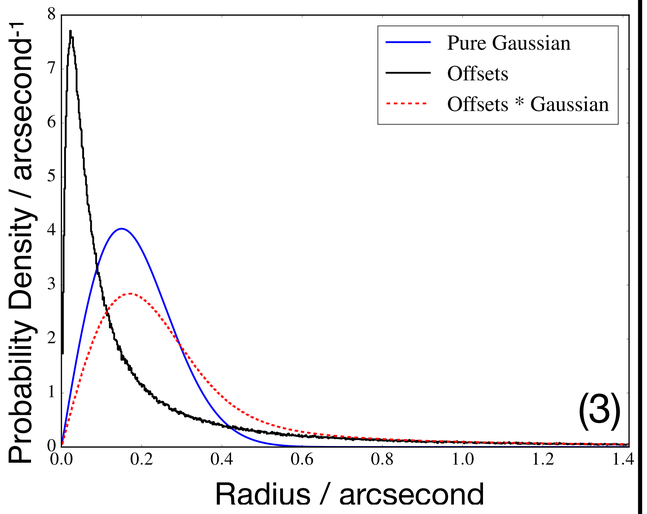


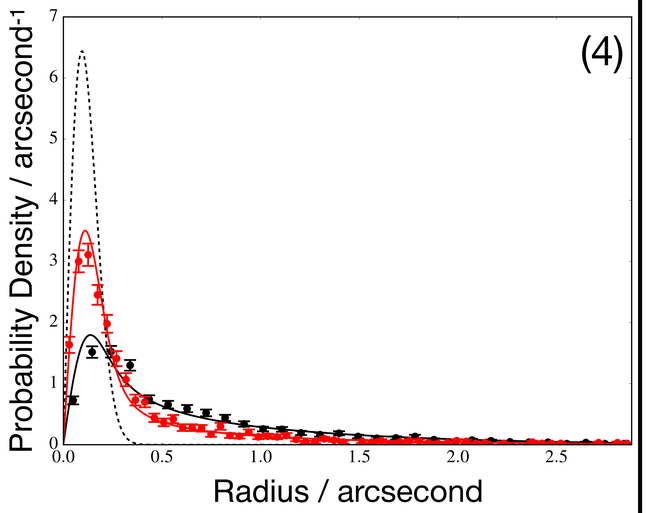


The density of sky sources should be constant, and these middle separation objects should exist. They have been absorbed into the bright central object. This is shown graphically in Figure (2). The astrometry of the *Gaia* source is precise, and the more uncertain *WISE* source might be recorded at its position in the absence of these absorbed contaminants. However, the contaminant perturbs the *WISE* source, resulting in a new sky position.

The description of the measured position of a source, its astrometric uncertainty function (AUF), is not purely dependent on the effects of the telescope optics and noise. The AUF is a convolution of this function, usually a Gaussian, and a description of the systematic shifts, shown in Figure (3).
The non-Gaussianity of the AUF is highlighted in Figure (4), where a Gaussian *WISE* AUF (dotted line) is wholly unable to explain *Gaia*-*WISE* separations, shown for two levels of sky crowding (red and black points and lines).

This is vitally important when combining precision astrometry with legacy datasets.
Source crowding means it cannot be assumed that the description of the separations between potential cross-match counterparts follows Gaussian statistics.





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