ON THE OPTIMIZATION OF FLUX ESTIMATES

H. Hensberge¹ and M. David²

¹ *Royal Observatory of Belgium, Ringlaan 3, B-1180 Brussels, Belgium*

² *University of Antwerp (RUCA), B-2020 Antwerp, Belgium*

Received September 6, 2000.

Key words: methods: data analysis – techniques: image processing

A problem, common to astronomical spectroscopy and photometry, is the definition of an estimator of the light intensity of a point-source (usually differential to a reference level). This estimator should be correct and precise (unbiased, minimum variance). Spectroscopists and photometrists have tackled this problem from different viewpoints, because their major concern (variance in spectroscopy, impurity of the PSF wings due to competing light sources in photometry) is different. We discuss how both approaches are related to each other and argue that the gain in variance and the risk of bias should be compared when selecting the “optimal” flux estimation method. In the electronic version (available by anonymous ftp to omaftp.oma.be and retrieval of /dist/astro/herman/jenam2000/hhmd.ps) we present general expressions for the maximum gain in variance obtainable for a given photon density and for the flux levels below which the real gain is near to the maximum one, and we apply them to 1-D and 2-D Gaussian and Moffat distributions (Fig. 1), leaving the cut-off radius of the extraction aperture as a free parameter.

For apertures that include the bulk of the photon density distribution, the gain in signal-to-noise ratio in a minimum variance algorithm (relative to summing the flux over all valid data in the aperture) is seen to be much larger in 2-D (photometry) than in 1-D (spectroscopy). Even with well-developed wings, the gain in the 1-D case does not exceed the gain for a 2-D Gaussian distribution, suggesting that especially in spectroscopy bias introduced by optimal extraction could counteract the gain in variance.

Finally, we point out that bias introduced by a minimum-variance algorithm (because of incorrect model assumptions) depends non-linearly

Fig. 1. Gain in variance for specific distributions (x for 1-D, r for 2-D G (aussian) and M (offat) distribution) and for different extraction apertures. The coordinate on the horizontal axis scales with the aperture radius and is normalized to 1 for an aperture including 95% of the total flux.

on the flux to be estimated. In spectroscopy, this means that the systematic error depends on the spectral structure; in photometry, this means that the brightness-ratio of faint and bright objects is altered.

ACKNOWLEDGMENT. H.H. acknowledges the support by IUAP P4/05 of the Belgian DWTC/SSTC.