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COMBINING APERTURE AND PSF-FITTING PHOTOMETRY

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Abstract.
The multiple object and multiple frame (MOMF) CCD photometry package, that combines the advantages of aperture and PSF photometry is described. Results from comparisons with other programs are given; no other photometry package was found to give better results than MOMF.

Key words: techniques: photometric

1. INTRODUCTION

There is a long-standing discussion concerning CCD photometry: what is the best method – aperture photometry or Point-Spread-Function (PSF) fitting?

The answer to this question accepted by most people is: aperture photometry, where a software aperture with adjustable radius is used to calculate the stellar fluxes on the CCD frames, works best for bright, isolated stars, whereas PSF fitting, where the distribution of the star light in the images is fitted to all objects on the frame, works better for faint stars and for objects in crowded fields.

However, wouldn't it be good to combine the advantages of both methods to achieve best results for all stars on a given frame with a consistent methodology? Of course it is, and it has already been done more than 10 years ago with the program MOMF (Multiple Object Multiple Frame Photometry, Kjeldsen & Frandsen 1992).

2. MOMF

The program performs CCD photometry on reduced frames, i.e. basic data reduction like overscan, bias, dark count and flat field corrections as well as trimming must have been done earlier with other software.

MOMF then creates a fiducial frame for star identification and goes non-interactively through the following steps to perform the actual photometry:

- Determination of an *empirical* PSF for each frame
- Subtraction of all identified stars
- Re-determination of sky background on star-subtracted frame
- Re-determination of PSF and again subtraction of all stars
- Aperture photometry correction on the residuals

The aperture radii for the correction are specfied by the user and scale with seeing. Finally, the program combines the data relative to a freely selectable ensemble of comparison stars optimally to result in the lowest possible point-to-point scatter in the target star light curve; some weighting is also possible.

The main improvement over conventional photometry algorithms is the aperture correction that is performed on the residual stellar images on PSF-subtracted frames. The uncertainty of the PSF is largest in its centre because this is where the absolute number of counts and thus absolute amount of photon noise is largest (see Fig. 1). However, the radii for the aperture correction are much smaller than the ones for normal aperture photometry as only the innermost region of the stellar PSF contains residual flux. Consequently, the influence of sky background noise on the extracted stellar magnitudes is minimised.

Other advantages of this method are the accurate determination of sky background from the star-subtracted frames (most important for faint stars as most white dwarfs!) and that the resulting magnitudes do usually not correlate with the mean magnitudes of the stars and seeing.

Some shortcomings of this program must also be mentioned. It is not easy to learn and it takes quite some experience until one knows all the necessary and possible options. The program is somewhat fragile, e.g. one needs to take care that all stars in the field to be measured do not drift off the frame and the program cannot

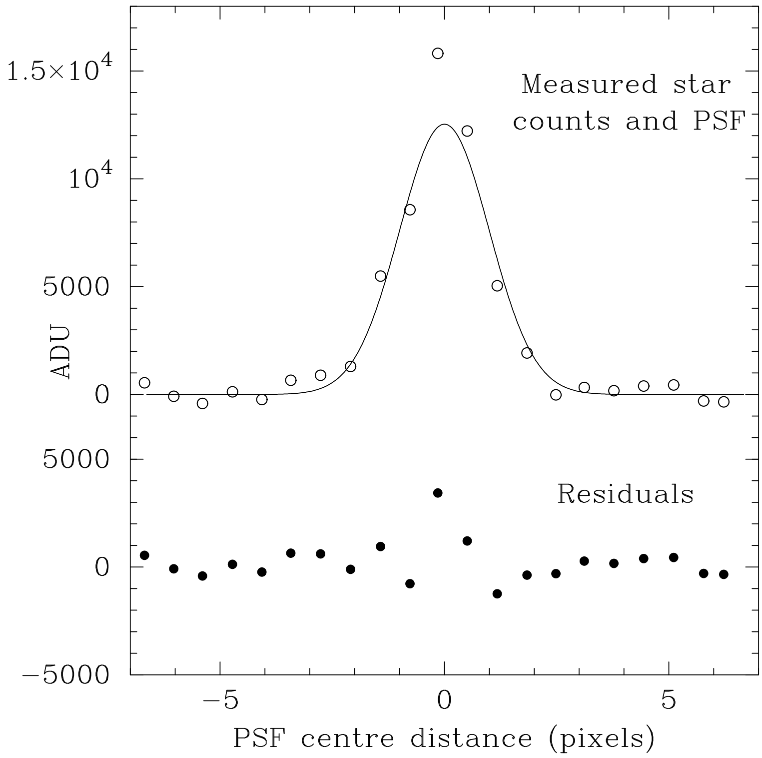

Fig. 1. Upper part: cut through a measured stellar image and a Gaussian PSF fitted to it. Lower part: residuals from the PSF fit; they are largest near the PSF centre.

cope with rotation of the field during a run. Finally, because of the sophisticated photometry algorithm it is somewhat slower than conventional CCD photometry programs.

3. COMPARISON TO OTHER METHODS AND AVAILABILITY

I have compared MOMF results with those other CCD photometry software on a number of data sets for pulsating white dwarfs. In all cases, MOMF produced better results than anything else. I find that MOMF light curves have about 10–20% lower scatter than light curves produced with fitting of analytic PSFs, and I obtain at least 3% lower scatter than aperture photometry with Antonio Kanaan's scripts (used by Matt Wood, private communication) yielded. MOMF has also been applied to the standard WET test data set (O'Donoghue et al. 2000), but the result is not yet known.

LINUX and IRIX distributions of the latest MOMF version including manuals etc. are freely available at the following web site: `http://astro.ifa.au.dk/~srf/STACC`

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