J-MAPS Technical Memorandum 08-20

Astrometric Passband Polychromatic Weighting for Monochromatic Point Spread Functions

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ABSTRACT

In order to generate realistic, polychromatic PSFs for J-MAPS requirements analysis, we will use an approach that superposes high-fidelity monochromatic PSFs generated over separate passbands of the instrument's total spectral response region. The monochromatic PSFs must be weighted based on the input spectrum and the instrumental spectral response. This memorandum calculates the relative weighting for both low and high spectral resolution monochromatic PSFs as a function of spectral type and magnitude.

1. Introduction

Polychromatic point spread functions (PSFs) that span the system's full spectral response are critical to accurate data analysis for J-MAPS. Monochromatic PSFs for discrete spectral bands may be combined, each with its own respective weight, to make a polychromatic PSF that spans a much larger passband. A monochromatic PSF's weight is equal to the fraction of photoelectron counts in that PSF's bandpass over the total number of photoelectron counts in the polychromatic PSF's passband. Because the weights for individual PSFs are different for each spectral type, spectra for 10 different spectral types from Pickles (1998) are used to calculate the weights for both current, low spectral resolution and future, high spectral resolution PSFs.

2. Methodology

For each of 10 selected spectral types, the Pickles (1998) spectra was first convolved with the spectral throughput of the J-MAPS optical system, shown in Figure 1, which includes the quantum efficiency of the H4RG detector and the spectral reflectivity of the mirrors. Because the J-MAPS astrometric passband is most sensitive from 700-900 nm, cool, red stars are of particular importance. Therefore, the selected spectra include M1, M5, and M6; the latter is the latest type available from the Pickles library.

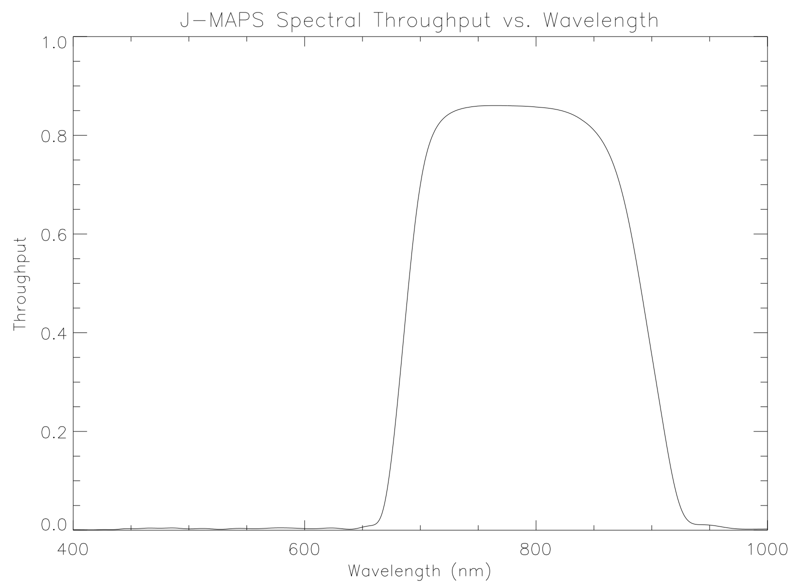

Figure 1: J-MAPS Spectral Throughput

The resulting spectra, in units of photoelectrons per second, were then integrated, in wavelength bins of 0.5 nm, over each monochromatic PSF bandpass. Once the count rate for each monochromatic PSF's bandpass had been determined, the weight for each PSF was calculated by dividing the appropriate region's photoelectron count rate by the photoelectron count rate of all regions combined. The weight, then, is the fraction of total photoelectron counts in the PSF's waveband region. Two sets of monochromatic PSFs were weighted to prepare two polychromatic PSFs. In the first set, the current, low spectral resolution PSFs include regions 400-650nm, 650-750 nm, 750-850 nm, and 850-1000 nm respectively. In the second set, high spectral resolution PSFs include regions 400-600 nm, 600-650 nm, 650-700 nm, 700-750 nm, 750-800 nm, 800-850 nm, 850-900 nm, 900-950 nm, and 950-1000 nm passbands for use in future analysis.

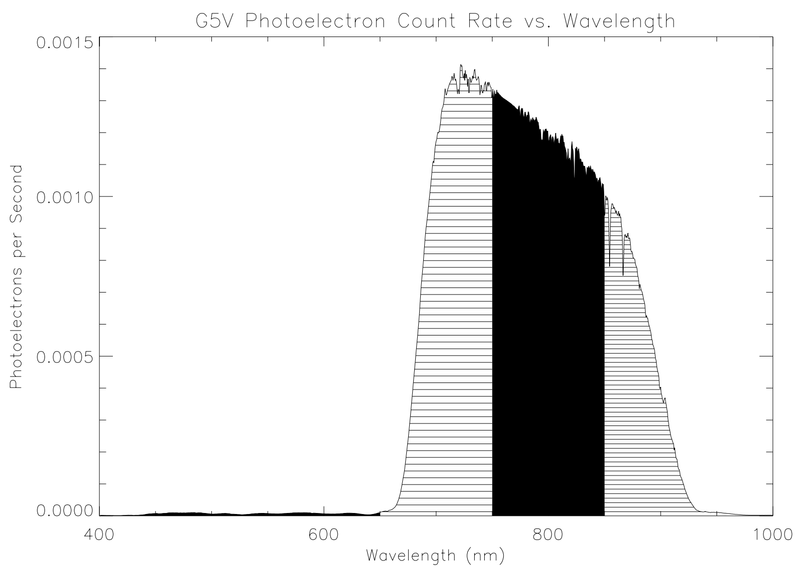

Figure 2: Spectra Convolved with J-MAPS Throughput and Integrated over Monochromatic PSF Passbands

Note: Monochromatic Passbands are 400-650, 650-750, 750-850, and 850-1000nm. Also, the photoelectron count rate has been normalized over the region 400-1000nm.

3. Lower Spectral Resolution Weighting Coefficients

The weights for current, low spectral resolution PSFs for ten stellar spectral types are presented in Table 1.

Table 1: Weights for Lower Spectral Resolution PSFs

Spectral Type	PSF1 400-650	PSF2 650-750	PSF3 750-850	PSF4 850-1000
05	0.0568	0.3970	0.4152	0.1310
09	0.0548	0.3950	0.4208	0.1299
A5	0.0245	0.3669	0.4486	0.1599
B5	0.0384	0.3755	0.4411	0.1450
F5	0.0143	0.3508	0.4665	0.1684
G5	0.0100	0.3415	0.4719	0.1766
K4	0.0051	0.3222	0.4816	0.1911
M1	0.0027	0.2638	0.5090	0.2245
M5	0.0008	0.1822	0.5326	0.2844
M6	0.0004	0.1488	0.5308	0.3200

Note: Weights are unitless. The sum of each spectral type's weights is 1. The passbands for each PSF region are given in nm.

4. Higher Spectral Resolution Weighting Coefficients

Higher spectral resolution PSFs will support more detailed spectral analysis in the future. The weights for these PSFs for all the spectral types are presented in Table 2.

Table 2: Weights for Higher Spectral Resolution PSFs

Spectral Type	PSF1 400-600	PSF2 600-650	PSF3 650-700	PSF4 700-750	PSF5 750-800	PSF6 800-850	PSF7 850-900	PSF8 900-950	PSF9 950-1000
05	0.0547	0.0021	0.0986	0.2983	0.2339	0.1813	0.1142	0.0163	0.0005
09	0.0527	0.0021	0.0975	0.2971	0.2376	0.1832	0.1137	0.0157	0.0005
A5	0.0229	0.0017	0.0876	0.2793	0.2471	0.2016	0.1387	0.0205	0.0007
B5	0.0365	0.0019	0.0913	0.2842	0.2449	0.1962	0.1265	0.0178	0.0006
F5	0.0128	0.0015	0.0808	0.2700	0.2493	0.2173	0.1461	0.0216	0.0008
G5	0.0087	0.0013	0.0770	0.2646	0.2504	0.2214	0.1525	0.0233	0.0009
K4	0.0040	0.0010	0.0697	0.2525	0.2516	0.2300	0.1646	0.0256	0.0009
M1	0.0020	0.0007	0.0479	0.2159	0.2531	0.2559	0.1915	0.0317	0.0013
M5	0.0006	0.0002	0.0223	0.1599	0.2264	0.3061	0.2385	0.0441	0.0018
M6	0.0003	0.0001	0.0164	0.1323	0.2042	0.3266	0.2638	0.0538	0.0024

Note: Weights are unitless. The sum of each spectral type's weights is 1. The passbands for each PSF region are given in nm.

5. Summary

Weights for both current and future PSFs were calculated as a function of main sequence stellar spectral type using the spectral throughput of the J-MAPS optical system.

6. References

Pickles, A. 1998, PASP, 110, 749, 863