J-MAPS Technical Memorandum 08-13

Estimated J-MAPS Count Rates

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ABSTRACT

The anticipated photoelectron count rates generated on the H4RG Hybrid Complementary Metal-Oxide Semiconductor detector from stars with spectral types O5 to M6 and apparent visual magnitudes 0 to 16 are calculated using the zero point flux density for the Johnson V-band, the spectra of the main sequence stars, and the spectral throughput of the J-MAPS optical system.

1. Introduction

J-MAPS instrument requirements necessitate accurate predictions for astrometric centroiding capabilities, faintness detection limits, and saturation levels. Each of these factors depends on the photoelectron count rates expected on the H4RG detector. The number of observed photons determines the astrometric centroiding capabilities as well as the apparent magnitudes of the faintest stars that can be detected with the J-MAPS optical system. Saturation limits for the brightest stars also cannot be estimated without these photoelectron counts. This memorandum describes the predicted counts resulting from all spectral types at apparent visual magnitudes 0-16, using the zero-point flux density, spectra from Pickles (1998), and the spectral throughput for the J-MAPS optical system.

2. Methodology

The predicted count rates for each spectral type at each magnitude were calculated starting with the zero-point flux ($f_\lambda{}'$) density for the Johnson V-band (500-590 nm), which is defined as the photon flux density for a zero-magnitude, A0-type star (Dorland 2007):

$$f_\lambda{}' = 9.969 \times 10^3 ph \times s^{-1} \times cm^{-2} \times nm^{-1} \tag{1}$$

where the aperture area is in units of cm^{-2} and the bandwidth is in units of nm^{-1}. To convert the flux density to a photon count rate, the zero-point flux density was multiplied by the baseline J-MAPS aperture area of 234 cm^2 and a V-bandwith of 90 nm:

$$f_\lambda{}'_{(J-MAPS)} = 2.09947 \times 10^8 ph \times s^{-1} \tag{2}$$

Given the zero point photon count rate for J-MAPS, the expected photon count rate (f) from main sequence stars at various apparent visual magnitudes (m_v) can be calculated using the formula:

$$m_v = -2.5 \times log\left(\frac{f}{f_\lambda{}'_{(J-MAPS)}}\right) \tag{3}$$

Spectra for O5, O9, B5, A5, F5, G5, K5, M1, M5, and M6 type main sequence stars were taken from Pickles (1998) and integrated over the Johnson V-band in wavelength bins of 0.5 nm to get the V-band photon count rate. The spectra were then scaled so that their V-band count rate was equal to the V-band count rate predicted from the zero-point flux for each magnitude. The scaled spectra were then multiplied by the spectral throughput of the optical system, plotted in Figure 1, which includes the quantum efficiency of the H4RG detector and the spectral reflectivity of the mirrors in the J-MAPS optical system. This spectral throughput determines the fraction of photons at each wavelength converted into electrons, thereby converting the photon count rate into an electron count rate.

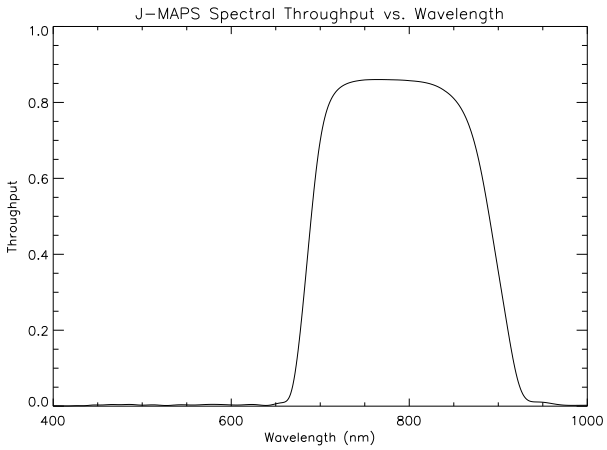

Figure 1: J-MAPS Spectral Throughput

Multiplying the scaled Pickles (1998) count rate for a specific spectral type and apparent visual magnitude by the spectral throughput gives the electron count rate as a function of

wavelength. The electron count rates were then integrated in wavelength bins of 0.5 nm over the 400 to 1000 nm band to get the total electron count rate for a specific spectral type at a specific apparent magnitude.

3. Data

The predicted electron count rates for spectral types O-K are presented in Table 1, and the predicted electron count rates for M stars are presented in Table 2.

Table 1: Electron Count Rates for Spectral Types O-K

m_v	O5V	O9V	B5V	A5V	F5V	G5V	K5V
0	1.165e+08	1.163e+08	1.446e+08	1.767e+08	2.377e+08	2.958e+08	4.7080e+08
1	46370000	46310000	57590000	70350000	94640000	1.1780e+08	1.874e+08
2	18460000	18440000	22930000	28010000	37680000	46890000	74610000
3	7350000	7340000	9127000	11150000	1500000	18670000	29700000
4	2926000	2922000	3633000	4439000	5972000	7432000	11830000
5	1165000	1163000	1447000	1770000	2377000	2959000	4708000
6	463700	463100	576000	703500	946400	1178000	1874000
7	184600	18440	229300	280100	376800	468900	746100
8	73500	73400	91270	111500	150000	186700	297000
9	29300	29220	36330	44390	59710	74320	118300
10	11650	11630	14470	17670	23770	29590	47080
11	4637	4631	5759	7035	9464	11780	18740
12	1846	1844	2293	2801	3768	4689	7461
13	735.0	734.0	912.7	1115	1500	1867	2970
14	293.0	292.2	363.3	443.9	597.1	743.2	1183
15	116.5	116.3	144.7	176.7	237.7	295.9	470.8
16	46.37	46.31	57.60	70.35	94.65	117.8	187.4

Table 2: Electron Count Rates for M Stars

m_v	M1V	M5V	M6V
0	8.288e+08	2.635e+09	4.474e+09
1	3.300e+08	1.050e+09	1.781e+09
2	1.314e+08	4.176e+08	7.091e+08
3	5230000	1.662e+08	2.823e+08
4	20820000	66180000	1.124e+08
5	8288000	26350000	44740000
6	3300000	10490000	17810000
7	1314000	4176000	7091000
8	523000	1662000	2823000
9	208200	661800	1124000
10	82880	263500	447400
11	33000	104900	178100
12	13140	41760	70910
13	5230	16620	28230
14	2082	6618	11240
15	828.8	2635	4474
16	330.0	1049	1781

Note: In both Table 1 and Table 2, count rates are given in units of electrons per second as a function of apparent visual magnitude and main sequence spectral type.

4. Summary

The expected photoelectron count rates for different spectral types and magnitudes were calculated. These predictions can now be used to estimate the astrometric centroiding capabilities, faintness limits, and saturation levels for all spectral types at varying magnitudes.

5. References

Dorland, B. 2008, J-MAPS Technical Memorandum 08-03

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