To: Distribution
From: M. Zombeck
Subject: **MathCad Model of HRC-I response to out of band radiation; Date: 3/10/99**

Predicted HRC-I QE based upon the following model parameters: $ORIGIN := 1$

HRC-I Flight Model UVIS (SN 004): Polyimide: 5520 +/- 193 A; Al: 763 +/-28 A

$t_{poly} := 5520 \cdot 10^{-8}$ cm

$t_{Al} := 763 \cdot 10^{-8}$ cm

These thicknesses are based on our laboratory x-ray measurements of SN004 witness samples TF101-1174 and TF101-1175.

The MCP QE is based upon the model in "Instrument Performance Model", M. Zombeck, 1995.

$$qe := \begin{bmatrix} 114 & .60 \\ 160 & .51 \\ 256 & .13 \\ 304 & .185 \\ 470 & .23 \\ 584 & .275 \\ 834 & .24 \\ 1024 & .24 \\ 1216 & .20 \\ 1400 & .20 \\ 1500 & .22 \\ 1600 & .20 \\ 1700 & .10 \\ 1800 & .06 \\ 1900 & .04 \\ 2000 & .01 \\ 2200 & .0001 \\ 2537 & 4 \cdot 10^{-7} \\ 5500 & 4.5 \cdot 10^{-11} \end{bmatrix}$$

The efficiency of CsI over the wavelength range 10 - 5500 A.

Sources:

10 - 2200 A, Barstow (1986), Martin & Bowyer (1982), Fraser, et al. (1982); 2537 A, Borovick-Romanov and Peskov (1994); 5500 A, Zombeck & Flanagan.

QE measurements are planned in EUV, UV, and visible light to improve this model. As soon as these measurements are available (approx. late 1999), they will be incorporated into the model.

The linear attenuation coefficients for polyimide and Al are given by

The polyimide attenuation coefficients are derived from our transmission measurements at Berkeley; the aluminum attenuation coefficients are from Hagemann, et al..

$$\mu := \begin{bmatrix} 100 & 2.5\cdot10^{4} & 3.6\cdot10^{5} \\ 200 & 9.9\cdot10^{4} & 2.7\cdot10^{4} \\ 304 & 3.1\cdot10^{5} & 3.5\cdot10^{4} \\ 470 & 4\cdot10^{5} & 4.3\cdot10^{4} \\ 584 & 5\cdot10^{5} & 5.4\cdot10^{4} \\ 834 & 4\cdot10^{5} & 8.5\cdot10^{4} \\ 1024 & 3.75\cdot10^{5} & 5\cdot10^{5} \\ 1216 & 3.5\cdot10^{5} & 1.1\cdot10^{6} \\ 1400 & 2.6\cdot10^{5} & 1.25\cdot10^{6} \\ 1500 & 2.6\cdot10^{5} & 1.3\cdot10^{6} \\ 1600 & 2.7\cdot10^{5} & 1.3\cdot10^{6} \\ 1700 & 2.8\cdot10^{5} & 1.35\cdot10^{6} \\ 1800 & 3.4\cdot10^{5} & 1.37\cdot10^{6} \\ 1900 & 3.5\cdot10^{5} & 1.38\cdot10^{6} \\ 2000 & 3.3\cdot10^{5} & 1.39\cdot10^{6} \\ 2200 & 3.0\cdot10^{5} & 1.42\cdot10^{6} \\ 2537 & 3.10\cdot10^{5} & 1.45\cdot10^{6} \\ 3000 & 2.5\cdot10^{5} & 1.48\cdot10^{6} \\ 4000 & 1.3\cdot10^{4} & 1.49\cdot10^{6} \end{bmatrix}$$

We will make a linear interpolation to define the QE everywhere over the band 100-2 $i := 1 .. 18$

Wavelength vector: $vx_i := qe_{i,1}$

QE vector: $vy_i := qe_{i,2}$

The interpolating function:

$$QElin(\lambda) := linterp(vx, vy, \lambda)$$

Fit the band 2000-2537 with an exponential function:

$$QEexp(\lambda, a, b) := a \cdot \exp(-b \cdot \lambda)$$

$i := 16 .. 18$

$$SSE(a,b) := \sum_i \left(qe_{i,2} - QEexp\left(qe_{i,1}, a, b\right)\right)^2$$

$a := 2.73 \cdot 10^{14}$ $b := 0.02$

Given

$SSE(a,b) = 0$ $1 = 1$

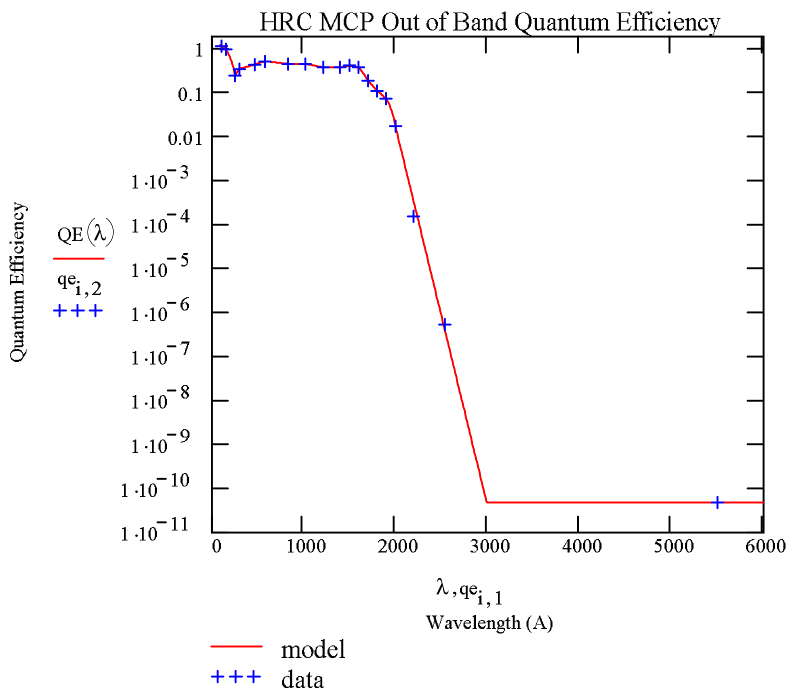
$$\begin{bmatrix} a \\ b \end{bmatrix} := Minerr(a,b) \qquad a = 6.7 \cdot 10^{14} \qquad b = 0.0$$

Fit the band 2537-2995 with the same exponential function and fit the band 3000-6000 A with a constant equal to the QE at 5500 A.

Construct a piecewise continuous function:

$$QE(\lambda) := if\left(\lambda \le 2000, QElin(\lambda), if\left(\lambda \le 2995, QEexp(\lambda, a, b), qe_{19,2}\right)\right)$$

A plot of QE: $i := 1 .. 19$ $\lambda := 100, 110 .. 6000$



We will make a linear interpolation to define μ for polyimide over the band 100-3000 A.

$$i := 1 .. 18$$

Wavelength vector:

$$vx_i := \mu_{i,1}$$

QE vector:

$$vy_i := \mu_{i,2}$$

The interpolating function:

$$\mu_{polylin}(\lambda) := \text{linterp}(vx, vy, \lambda)$$

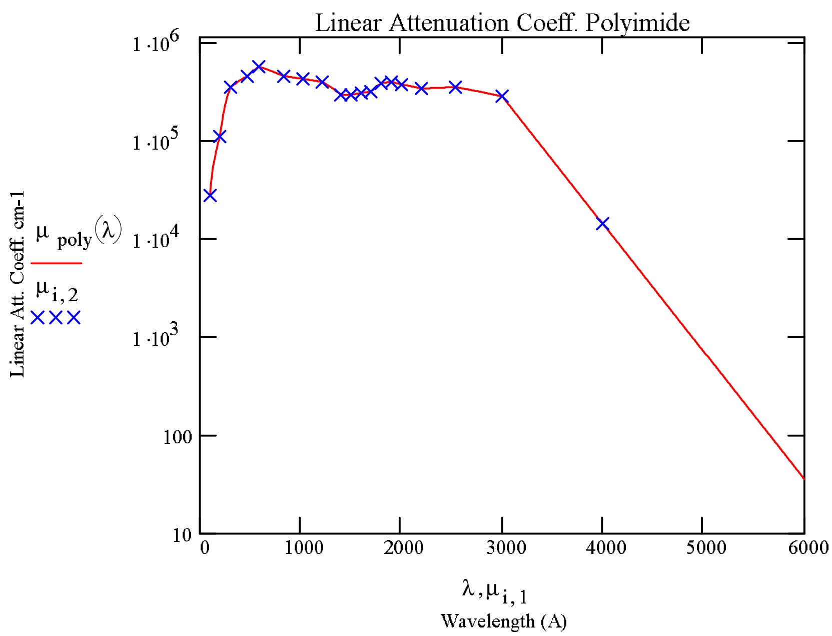
Fit the band 3000-6000A with an exponential.

$$\mu_{polyexp}(\lambda) := 1.778 \cdot 10^{9} \cdot \exp\left(-2.957 \cdot 10^{-3} \cdot \lambda\right)$$

$$\mu_{poly}(\lambda) := \text{if}\left(\lambda \le 3000, \mu_{polylin}(\lambda), \mu_{polyexp}(\lambda)\right)$$

A plot of μ:

$$\lambda := 100, 110 .. 6000 \qquad i := 1 .. 19$$



We will make a linear interpolation to define μ for aluminum everywhere over the band.

$i := 1 .. 19$

Wavelength vector:

$vx_i := \mu_{i,1}$

QE vector:

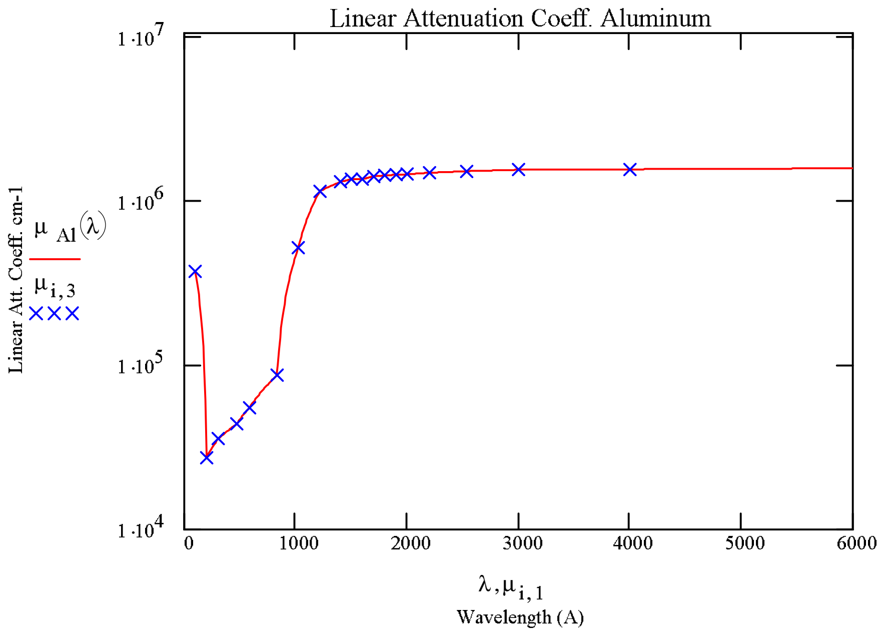
$vy_i := \mu_{i,3}$

The interpolating function:

$\mu_{Al}(\lambda) := \mathrm{linterp}(vx, vy, \lambda)$

A plot of μ:

$\lambda := 100, 110 .. 6000$



In order to model the transmission in the visible and near UV we will use witness sample file: tf1174.prn

Sample description: TF101-1174, R/N 06788-8, 795A Al:Si 5300A Polyimide
Read in the spectrophotometer scan data:

scandata := READPRN("tf1174.prn")

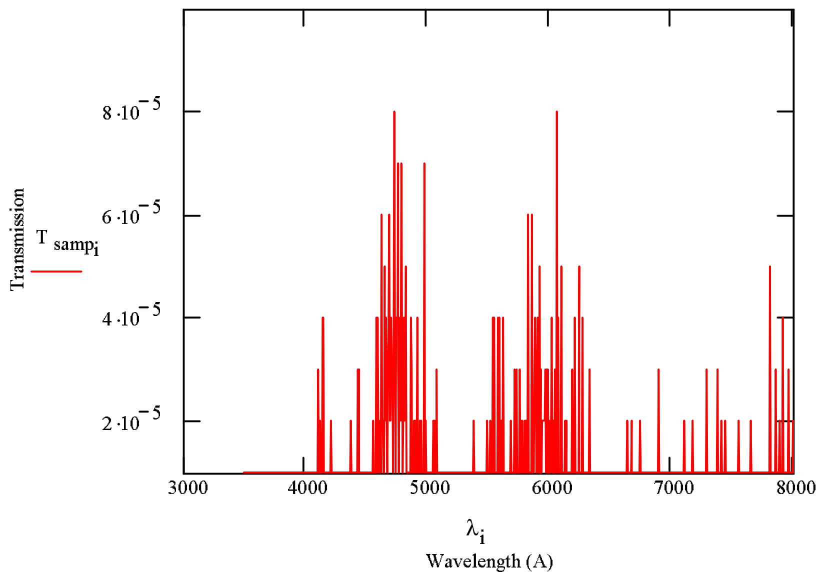
Define variables:

$\lambda := scandata^{<1>}$ wavelength vector (unit is Angstroms)

$T_{samp} := scandata^{<2>}$ transmission vector

Set negative transmissions to 0.0:

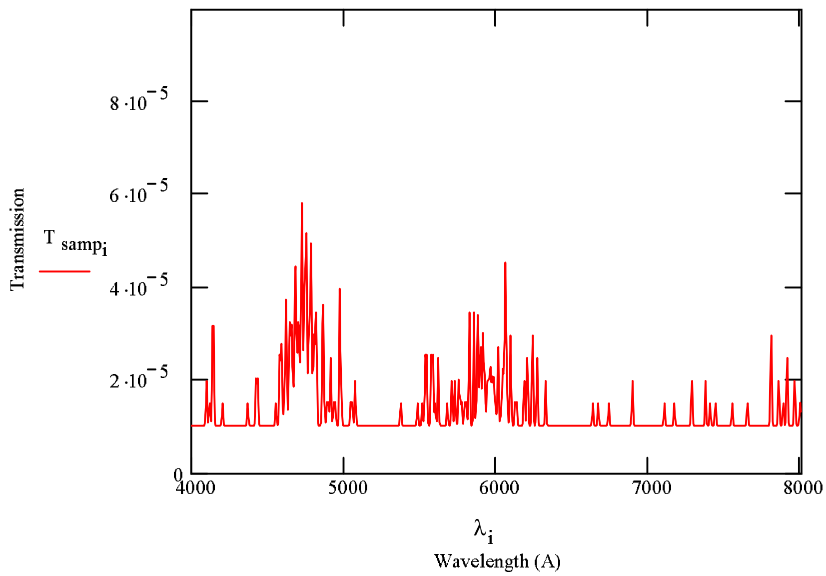
$i := 300 .. 1201$ $\quad T_{samp_i} := if\left(T_{samp_i} \le 0, 1 \cdot 10^{-5}, T_{samp_i}\right)$



We will smooth the above data using a running median smoother.

$$T_{samp} := \mathrm{ksmooth}\left(\lambda, T_{samp}, 11\right)$$

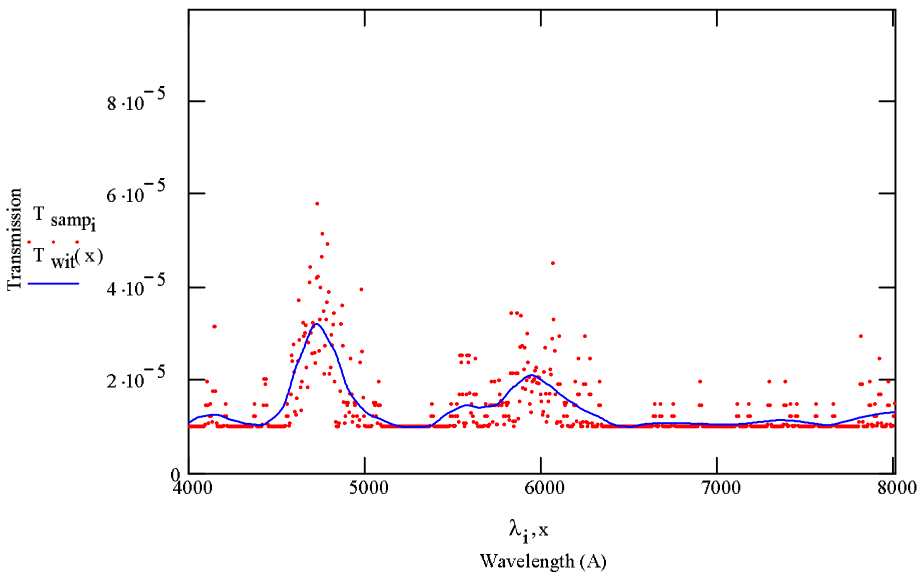
$$i := 401 .. 1201$$



$vs := loess(\lambda, T_{samp}, .1)$

$T_{wit}(x) := interp(vs, \lambda, T_{samp}, x)$

$x := 4000, 4005 .. 8000$



As a reality check calculate visible light transmission:

$$T_{vis} := \frac{\int_{4000}^{7000} T_{wit}(x)\,dx}{(7000 - 4000)} \qquad T_{vis} = 1.4 \cdot 10^{-5}$$

The measured (by Luxel) transmission of the witness sample for the FM shield is $3.73x10^{-5}$.

We will model the transmission of the UVIS using a slab model below 4400 A:

$T(\lambda) := \mathrm{if}\left(\lambda \le 4400, \exp\left(-\mu_{poly}(\lambda)\cdot t_{poly}\right)\cdot\exp\left(-\mu_{Al}(\lambda)\cdot t_{Al}\right), T_{wit}(\lambda)\right)$

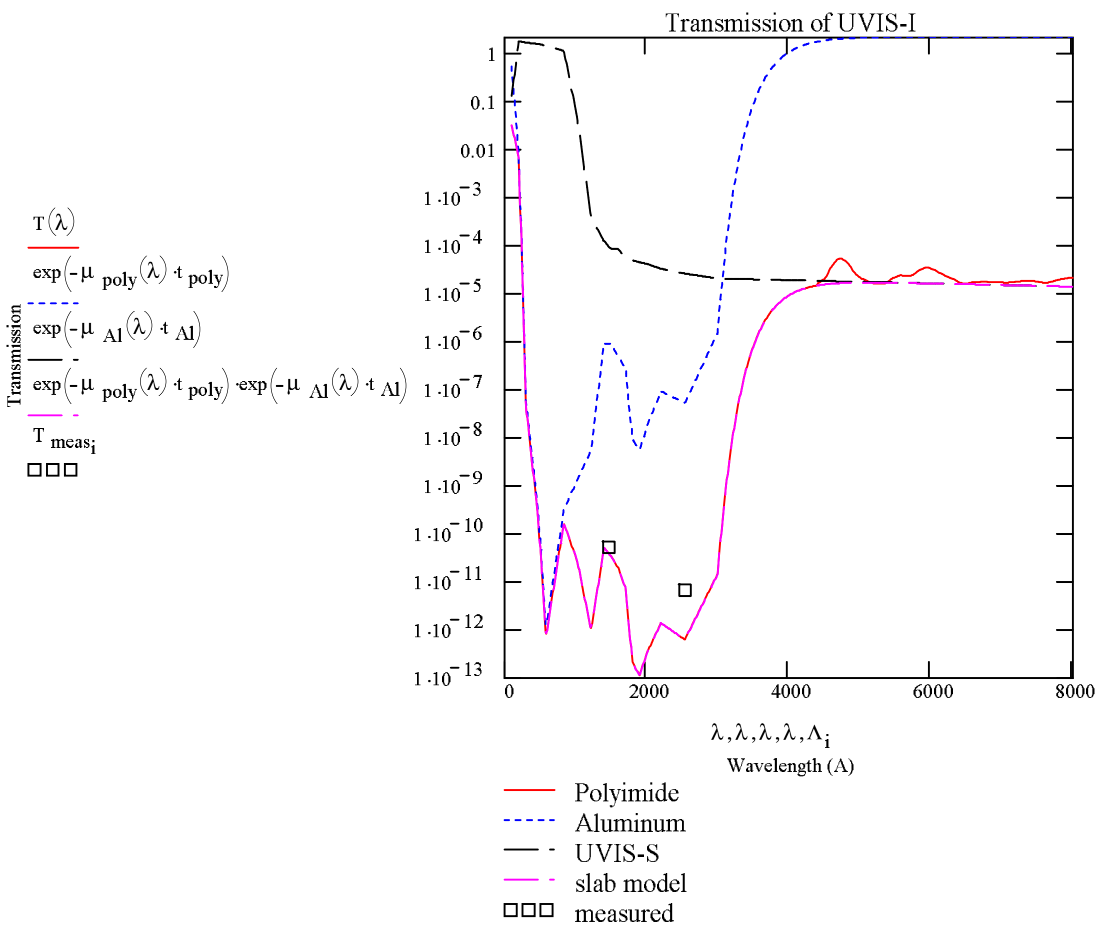
Measured values:

$T_{meas_1} := 4.4\cdot 10^{-11}$ $\quad \Lambda_1 := 1470$

$T_{meas_2} := 5.8\cdot 10^{-12}$ $\quad \Lambda_2 := 2537$

A plot of T:

$\lambda := 100, 110 .. 8000$ $\qquad i := 1 .. 2$



The qe of HRC-I for is then:

$QE_{UVIS}(\lambda) := T(\lambda) \cdot QE(\lambda)$

Measured values:

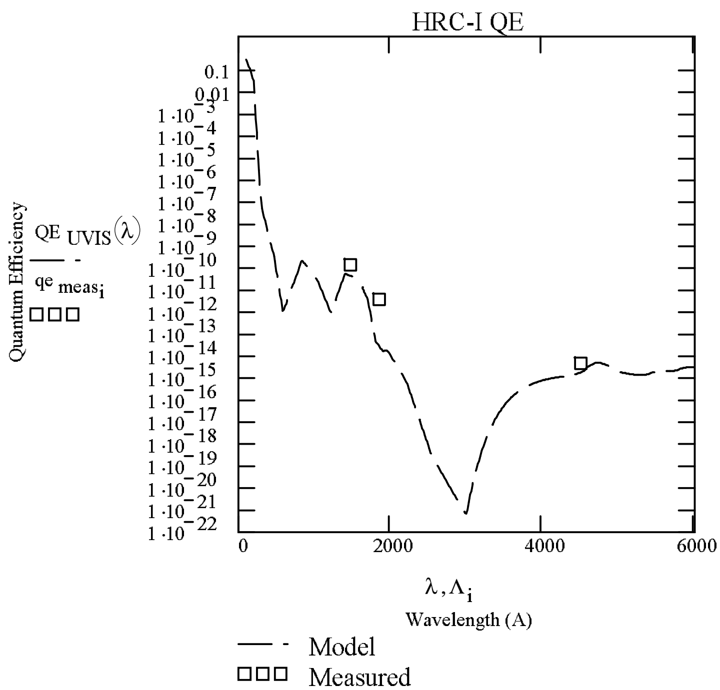
$qe_{meas_1} := 2.0 \cdot 10^{-11}$ $\Lambda_1 := 1470$

$qe_{meas_2} := 6.9 \cdot 10^{-13}$ $\Lambda_2 := 1850$

upper limit $qe_{meas_3} := 1.3 \cdot 10^{-15}$ $\Lambda_3 := 4500$

A plot of QE_{UVIS}:

$\lambda := 100, 110 .. 6000$ $i := 1 .. 3$



Write models to files:

Define wavelength and transmission vector and transmission matrix:

$i := 1 .. 591$

$lambda_i := 100 + (i - 1) \cdot 10$ $\quad Tr_i := T(lambda_i)$

$trans := augment(lambda, Tr)$

$WRITEPRN("hrci\_uvt.prn") := trans$

Define wavelength and mcp qe vector and qe matrix:

$i := 1 .. 591$

$lambda_i := 100 + (i - 1) \cdot 10$ $\quad QEv_i := QE(lambda_i)$

$qemcp := augment(lambda, QEv)$

$WRITEPRN("hrci\_uvmcpqe.prn") := qemcp$

Define wavelength and hrc-i qe vector and qe matrix:

$i := 1 .. 591$

$lambda_i := 100 + (i - 1) \cdot 10$ $\quad QEv_{UVIS_i} := QE_{UVIS}(lambda_i)$

$eff := augment(lambda, QEv_{UVIS})$

$WRITEPRN("hrci\_uvqe.prn") := eff$

Count rate estimates for astronomical objects:

We will estimate the count rate for a star with a blackbody spectrum.
The spectral photon irradiance for a star at temperature T_e and bolometric apparent magnitude m_b is given by

$$f(\lambda, T_e, m_b) := \frac{8.48\cdot 10^{34}\cdot 10^{-0.4\cdot m_b}}{T_e^{\,4}\cdot\lambda^4\cdot\left(\exp\left(\frac{1.44\cdot 10^8}{\lambda\cdot T_e}\right)-1\right)}$$ photons cm^{-2} s^{-1} A^{-1}

For an A0 star the bolometric correction is

$$BC := -0.40$$

and the effective temperature is

$$T_e := 10800$$

For an A0 star of visual apparent magnitude

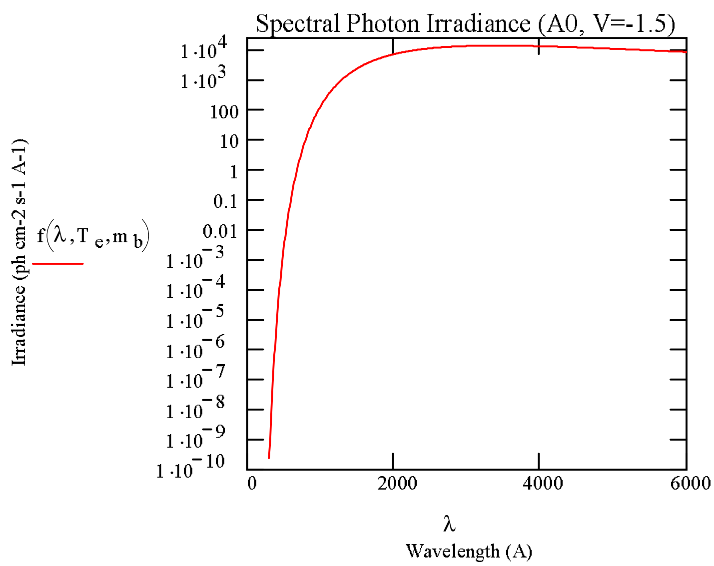
$$V := -1.5$$

The apparent bolometric magnitude is

$$m_b := BC + V \qquad m_b = -1.9$$

A plot of the spectral photon irradiance for this star:

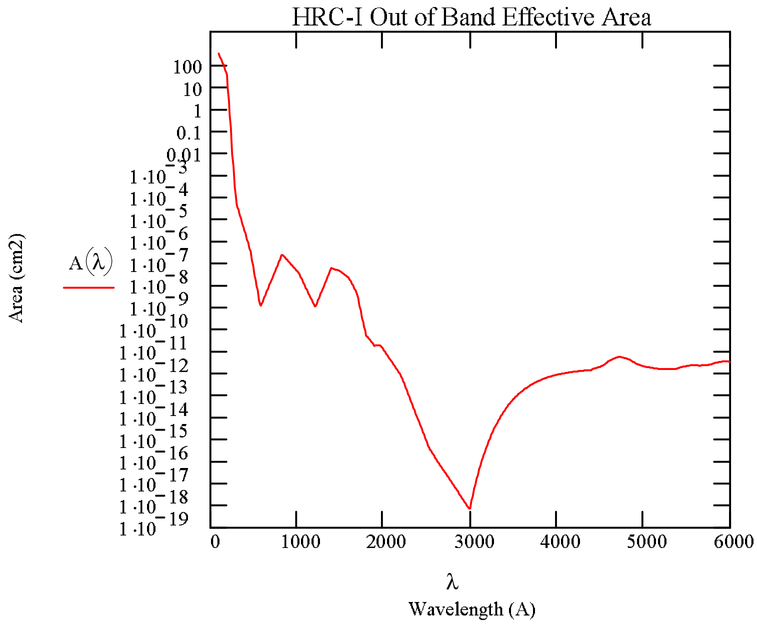
$$\lambda := 300, 310 .. 6000$$



The effective area of HRC-I is the product of the QE with the HRMA area (1100 cm^2):

$A(\lambda) := QE_{UVIS}(\lambda) \cdot 1100$

$\lambda := 100, 110 .. 6000$



Define wavelength and hrc-i qe vector and qe matrix:

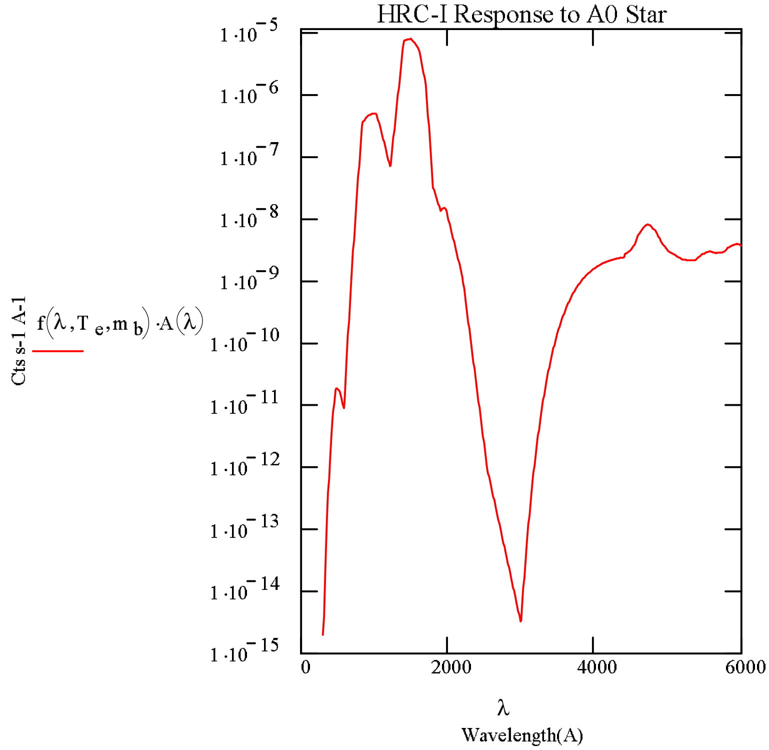
$i := 1 .. 591$

$lambda_i := 100 + (i - 1) \cdot 10$ $\quad Av_i := A(lambda_i)$

$effarea := augment(lambda, Av)$

WRITEPRN("hrciuv_a.prn") := effarea

Folding the stellar spectrum with the area of HRC-I: $\lambda := 300, 310 .. 6000$



The estimated count rate for HRC-I in the band 300 - 6000 A is the area under this curve:

$$CR := \int_{300}^{6000} f(\lambda, T_e, m_b) \cdot QE_{UVIS}(\lambda) \cdot 1100 \, d\lambda \qquad CR = 1.92 \cdot 10^{-3}$$ ct s-1

In 300-2500 and 2500-6000 A bands:

$$CR_{300\_2500} := \int_{300}^{2500} f(\lambda, T_e, m_b) \cdot QE_{UVIS}(\lambda) \cdot 1100 \, d\lambda \qquad CR_{300\_2500} = 1.9 \cdot 10^{-3}$$

ct s-1

$$CR_{2500\_6000} := \int_{2500}^{8000} f(\lambda, T_e, m_b) \cdot QE_{UVIS}(\lambda) \cdot 1100 \, d\lambda \qquad CR_{2500\_6000} = 9.52 \cdot 10^{-6}$$

ct s-1

Response to solar radiation:

The spectral photon irradiance for a star at temperature T_e and bolometric apparent magnitude m_b is given by

$$f(\lambda, T_e, m_b) := \frac{8.48 \cdot 10^{34} \cdot 10^{-0.4 \cdot m_b}}{T_e^{4} \cdot \lambda^{4} \cdot \left(\exp\left(\frac{1.44 \cdot 10^{8}}{\lambda \cdot T_e}\right) - 1\right)}$$ photons cm^{-2} s^{-1} A^{-1}

For the Sun, a G2 star, the effective temperature is

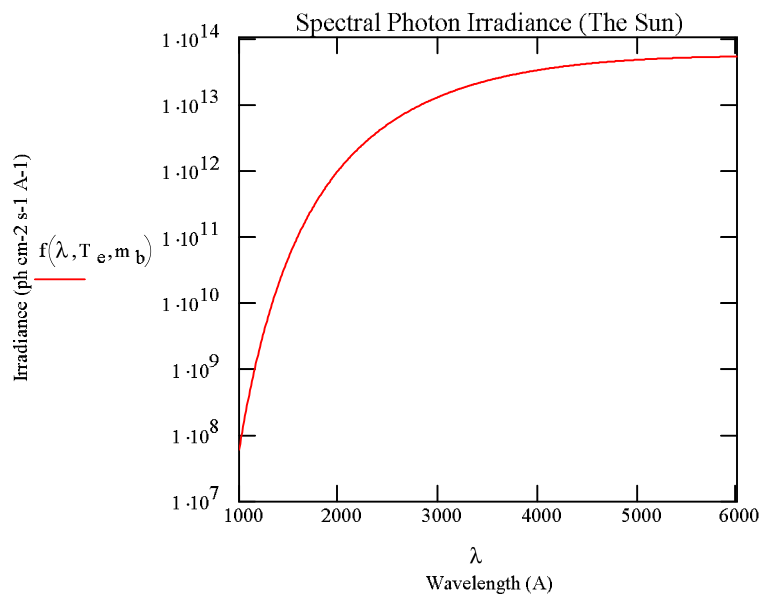
$$T_e := 5770$$

The apparent bolometric magnitude is

$$m_b := -26.82$$

A plot of the spectral photon irradiance of the Sun:

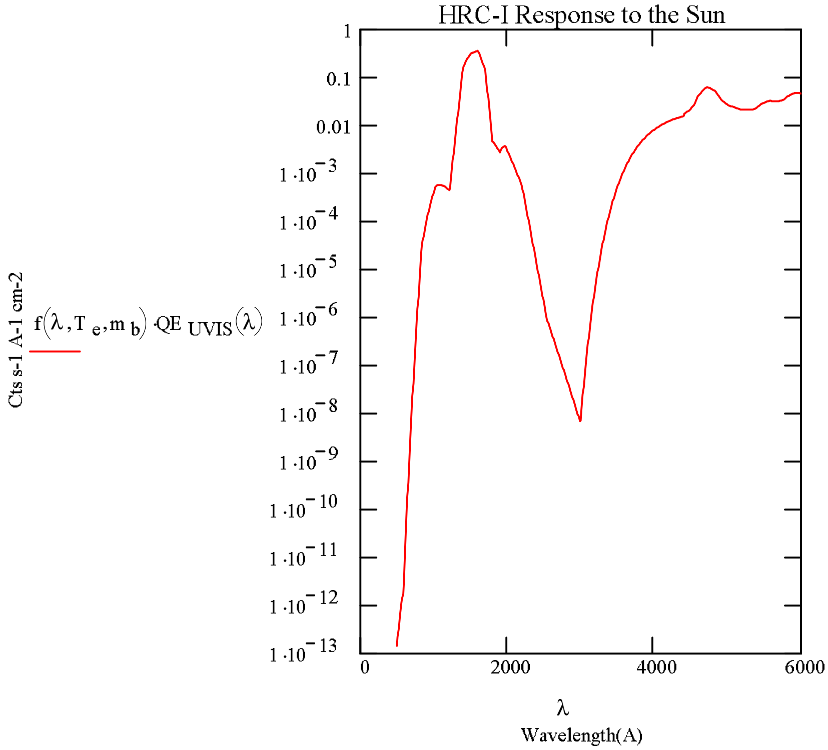
$\lambda := 1000, 1010 .. 6000$



The photon flux in the band 3000-6000:

$$flux := \int_{3000}^{6000} f(\lambda, T_e, m_b)\, d\lambda \qquad flux = 1.1 \cdot 10^{17}$$

$\lambda := 500, 510 .. 6000$



Assuming a point source transmission of: $PST := 1 \cdot 10^{-12}$

$$CR_{100\_3000\_Sun} := \int_{100}^{3000} PST \cdot f(\lambda, T_e, m_b) \cdot QE_{UVIS}(\lambda)\, d\lambda \qquad CR_{100\_3000\_Sun} = 9.0 \cdot 10^{-11}$$

ct cm^{-2} s^{-1}

$$CR_{3000\_8000\_Sun} := \int_{3000}^{6000} PST \cdot f(\lambda, T_e, m_b) \cdot QE_{UVIS}(\lambda)\, d\lambda \qquad CR_{3000\_8000\_Sun} = 6.0 \cdot 10^{-11}$$

ct cm^{-2} s^{-1}

Count rates from principle solar emission lines:

H I 1215.67 A

$$\phi_{1215} := \frac{1215.67 \cdot 10^{-8} \cdot 51 \cdot 10^{-4} \cdot 10^{-4} \cdot 10^{7}}{6.626 \cdot 10^{-27} \cdot 3 \cdot 10^{10}} \qquad \phi_{1215} = 3.1 \cdot 10^{11}$$

ph s^{-1} cm^{-2}

$$CR_{1215} := QE_{UVIS}(1215.7) \cdot \phi_{1215} \cdot PST \qquad CR_{1215} = 5.778 \cdot 10^{-14}$$

cts s^{-1} cm^{-2}

He II 303.8 A

$$\phi_{304} := \frac{303.8 \cdot 10^{-8} \cdot 2.5 \cdot 10^{-4} \cdot 10^{-4} \cdot 10^{7}}{6.626 \cdot 10^{-27} \cdot 3 \cdot 10^{10}} \qquad \phi_{304} = 3.8 \cdot 10^{9}$$

ph s^{-1} cm^{-2}

$$CR_{304} := QE_{UVIS}(304) \cdot \phi_{304} \cdot PST \qquad CR_{304} = 2.003 \cdot 10^{-11}$$

cts s^{-1} cm^{-2}

H I 1025.72 A

$$\phi_{1026} := \frac{1025.72 \cdot 10^{-8} \cdot 0.60 \cdot 10^{-4} \cdot 10^{-4} \cdot 10^{7}}{6.626 \cdot 10^{-27} \cdot 3 \cdot 10^{10}}$$

$$\phi_{1026} = 3.1 \cdot 10^{9}$$

ph s^{-1} cm^{-2}

$$CR_{1026} := QE_{UVIS}(1026) \cdot \phi_{1026} \cdot PST \qquad CR_{1026} = 1.618 \cdot 10^{-14}$$

cts s^{-1} cm^{-2}

C III 977 A

$$\phi_{977} := \frac{977 \cdot 10^{-8} \cdot 0.50 \cdot 10^{-4} \cdot 10^{-4} \cdot 10^{7}}{6.626 \cdot 10^{-27} \cdot 3 \cdot 10^{10}} \qquad \phi_{977} = 2.5 \cdot 10^{9}$$

ph s^{-1} cm^{-2}

$$CR_{977} := QE_{UVIS}(977) \cdot \phi_{977} \cdot PST \qquad CR_{977} = 2.07 \cdot 10^{-14}$$

cts s^{-1} cm^{-2}

Count rate estimates from several bright stars.

Spectra in the range 1200 - 3350 A have been retrieved from the IUE archive of calibrated low dispersion spectra. The visible spectra 3500 - 7000 A have been derived from calibrated spectra of parent type spectral type stars in Jacoby, Hunter, & Christian, 1984, AP J supp. **56**, 257. The parent spectra has been scaled in order to match the observed IUE spectra. The gap between 3350 A and 3500 A has been linearly interpolated.

Betelgeuse (M1-2Ia star; U=4.41 B=2.35 V=0.5)
Importing the star's spectrum: ORIGIN := 0

b_spectrum := READPRN("betelgeusespect.prn")

$wavel := b\_spectrum^{\langle 0\rangle}$ A $intensity := b\_spectrum^{\langle 1\rangle}$ erg s^{-1} cm^{-2} A^{-1}

Linear interpolation to create a continuous intensity function:

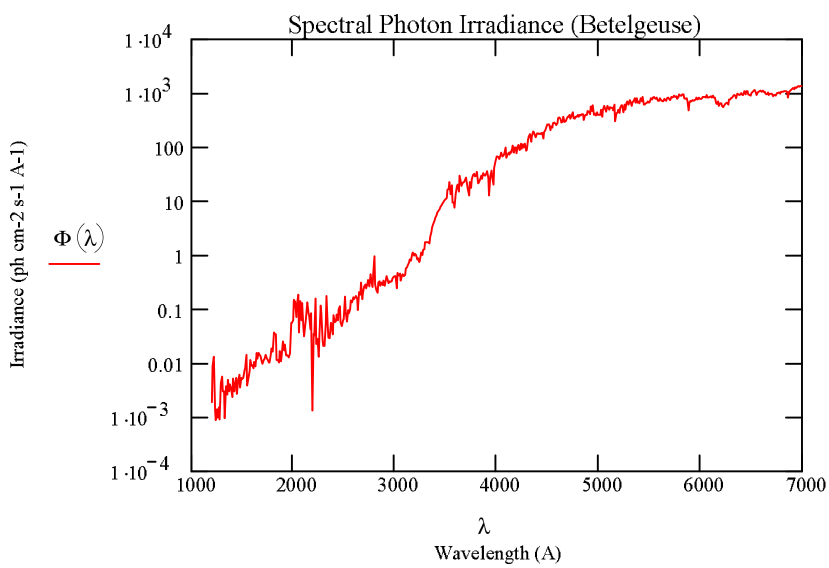
$$I(\lambda) := linterp(wavel, intensity, \lambda)$$

with $h := 6.6261 \cdot 10^{-27}$ erg s $c := 2.998 \cdot 10^{10}$ cm s^{-1}

the photon irradiance is given by

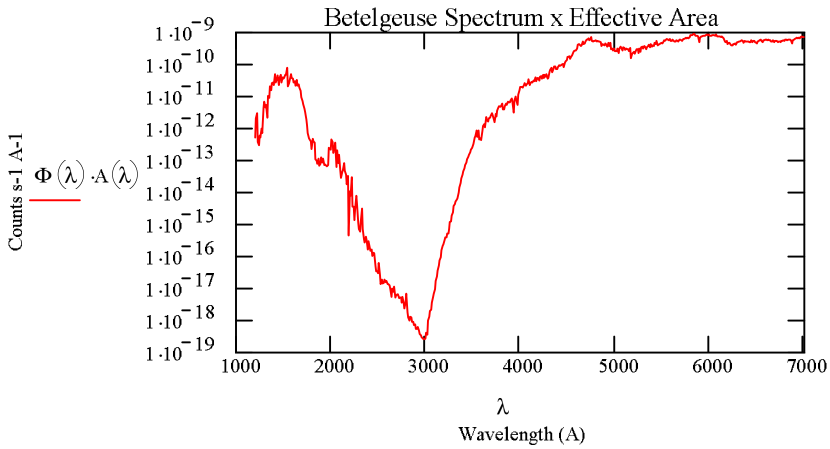
$$\Phi(\lambda) := I(\lambda) \cdot \left(\frac{\lambda \cdot 10^{-8}}{h \cdot c}\right)$$ photons cm^{-2} s^{-1} A^{-1}

A plot of the spectral photon irradiance: $\lambda := 1200, 1210 .. 7000$



Effective area model convolved with stellar spectrum to obtain count rate:

$\lambda := 1200, 1210 .. 7000$



Calculate count rate in various spectral bands:

$$\int_{1200}^{3000} \Phi(\lambda)\cdot A(\lambda)\,d\lambda = 1.0\cdot 10^{-8}$$ ct s^{-1}

$$\int_{3000}^{4000} \Phi(\lambda)\cdot A(\lambda)\,d\lambda = 1.9\cdot 10^{-9}$$ ct s^{-1}

$$\int_{4000}^{7000} \Phi(\lambda)\cdot A(\lambda)\,d\lambda = 1.3\cdot 10^{-6}$$ ct s^{-1}

$$\int_{1200}^{7000} \Phi(\lambda)\cdot A(\lambda)\,d\lambda = 1.3\cdot 10^{-6}$$ ct s^{-1}

Note: ROSAT HRI count rate: < 0.0005 ct s^{-1}

Beta Aurigae (A2 V star; U=1.98 B=1.93 V=1.85)

Importing the star's spectrum: ORIGIN := 0

b_spectrum := READPRN("betaaurspect.prn")

$wavel := b\_spectrum^{\langle 0 \rangle}$ A $intensity := b\_spectrum^{\langle 1 \rangle}$ erg s^{-1} cm^{-2} A^{-1}

Linear interpolation to create a continuous intensity function:

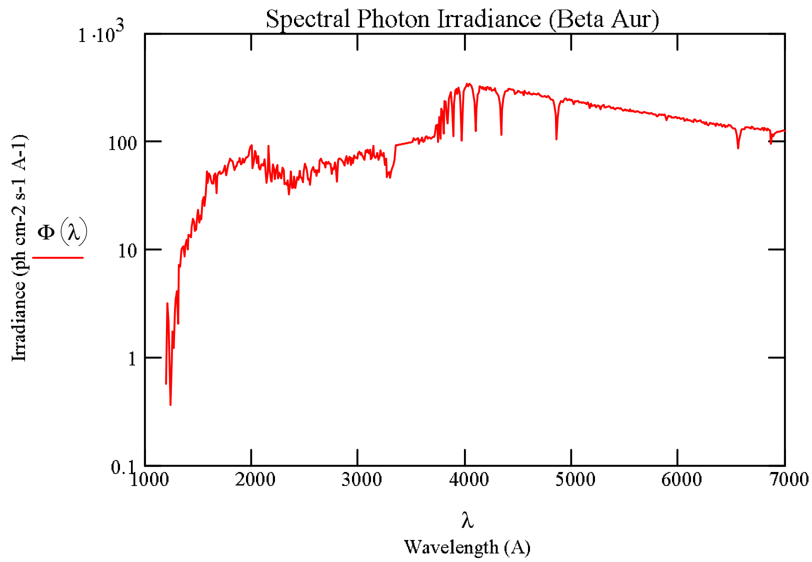
$I(\lambda) := linterp(wavel, intensity, \lambda)$

with $h := 6.6261 \cdot 10^{-27}$ erg s $c := 2.998 \cdot 10^{10}$ cm s^{-1}

the photon irradiance is given by

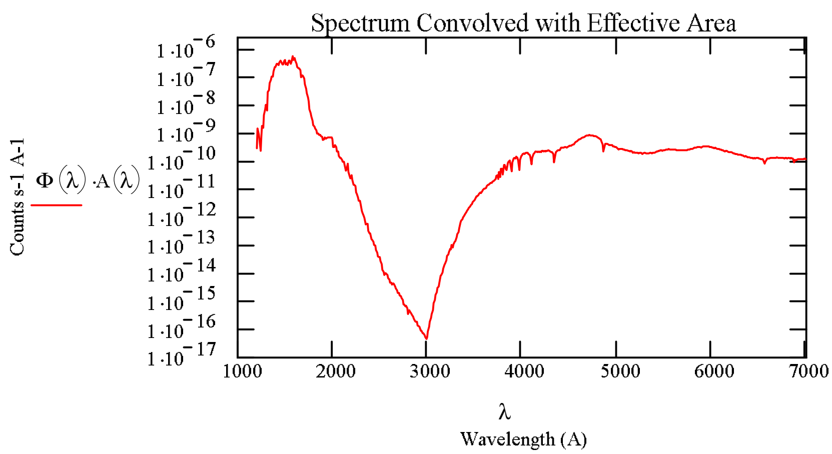
$$\Phi(\lambda) := I(\lambda) \cdot \left(\frac{\lambda \cdot 10^{-8}}{h \cdot c} \right)$$ photons cm^{-2} s^{-1} A^{-1}

A plot of the spectral photon irradiance: $\lambda := 1200, 1210 .. 7000$



Effective area model convolved with stellar spectrum to obtain count rate:

$\lambda := 1200, 1210 .. 7000$



Calculate count rate in various spectral bands:

$$\int_{1200}^{3000} \Phi(\lambda)\cdot A(\lambda)\,d\lambda = 4.2\cdot 10^{-5}$$ ct s^{-1}

$$\int_{3000}^{4000} \Phi(\lambda)\cdot A(\lambda)\,d\lambda = 1.3\cdot 10^{-8}$$ ct s^{-1}

$$\int_{4000}^{7000} \Phi(\lambda)\cdot A(\lambda)\,d\lambda = 4.0\cdot 10^{-7}$$ ct s^{-1}

$$\int_{1200}^{7000} \Phi(\lambda)\cdot A(\lambda)\,d\lambda = 4.1\cdot 10^{-5}$$ ct s^{-1}

Note: ROSAT HRI count rate: 0.0078 ct s^{-1}

Beta Carinae (A2 IV star; U=1.65 B=1.68 V=1.70)

Importing the star's spectrum: ORIGIN := 0

b_spectrum := READPRN("betacarspect.prn")

$wavel := b\_spectrum^{\langle 0 \rangle}$ A

$intensity := b\_spectrum^{\langle 1 \rangle}$ erg s^{-1} cm^{-2} A^{-1}

Linear interpolation to create a continuous intensity function:

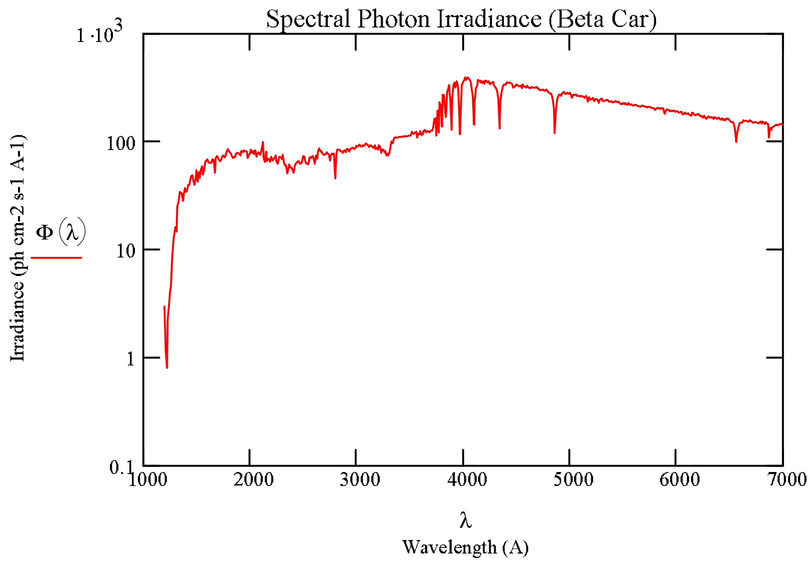
$I(\lambda) := linterp(wavel, intensity, \lambda)$

with $h := 6.6261 \cdot 10^{-27}$ erg s $c := 2.998 \cdot 10^{10}$ cm s^{-1}

the photon irradiance is given by

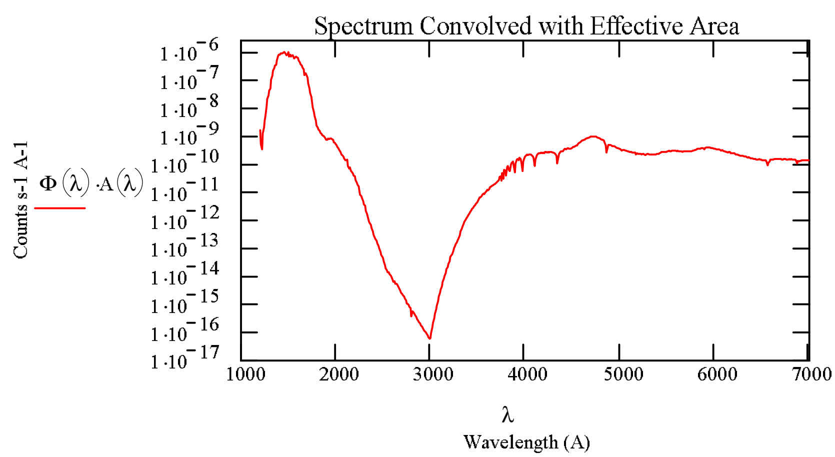
$$\Phi(\lambda) := I(\lambda) \cdot \left(\frac{\lambda \cdot 10^{-8}}{h \cdot c} \right)$$ photons cm^{-2} s^{-1} A^{-1}

A plot of the spectral photon irradiance for: $\lambda := 1200, 1210 .. 7000$



Effective area model convolved with stellar spectrum to obtain count rate:

$\lambda := 1200, 1210 .. 7000$



Calculate count rate in various spectral bands:

$$\int_{1200}^{3000} \Phi(\lambda)\cdot A(\lambda)\,d\lambda = 9.2\cdot 10^{-5} \quad \text{ct s}^{-1}$$

$$\int_{3000}^{4000} \Phi(\lambda)\cdot A(\lambda)\,d\lambda = 1.5\cdot 10^{-8} \quad \text{ct s}^{-1}$$

$$\int_{4000}^{7000} \Phi(\lambda)\cdot A(\lambda)\,d\lambda = 4.6\cdot 10^{-7} \quad \text{ct s}^{-1}$$

$$\int_{1200}^{7000} \Phi(\lambda)\cdot A(\lambda)\,d\lambda = 9.1\cdot 10^{-5} \quad \text{ct s}^{-1}$$

Note: ROSAT HRI count rate: 0.0111 ct s^{-1}

Rigel (B8 lab star; U=-0.57 B=0.09 V=0.12)
Importing the star's spectrum:

ORIGIN := 0

b_spectrum := READPRN("rigelspect.prn")

$wavel := b\_spectrum^{\langle 0 \rangle}$ A

$intensity := b\_spectrum^{\langle 1 \rangle}$ erg s^{-1} cm^{-2} A^{-1}

Linear interpolation to create a continuous intensity function:

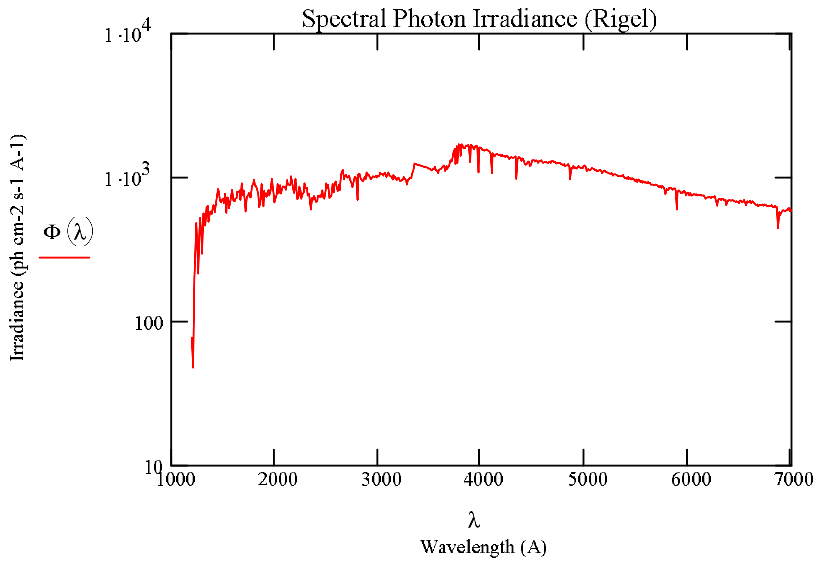
$I(\lambda) := linterp(wavel, intensity, \lambda)$

with $h := 6.6261 \cdot 10^{-27}$ erg s $c := 2.998 \cdot 10^{10}$ cm s^{-1}

the photon irradiance is given by

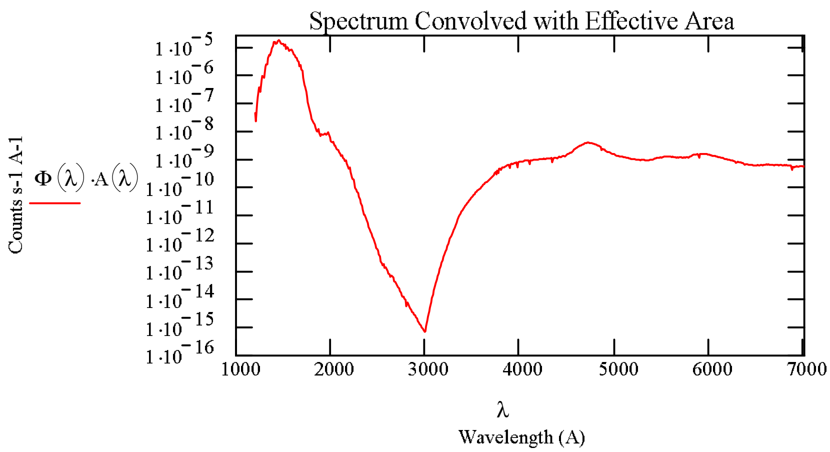
$$\Phi(\lambda) := I(\lambda) \cdot \left(\frac{\lambda \cdot 10^{-8}}{h \cdot c} \right)$$ photons cm^{-2} s^{-1} A^{-1}

A plot of the spectral photon irradiance: $\lambda := 1200, 1210 .. 7000$



Effective area model convolved with stellar spectrum to obtain count rate:

$\lambda := 1200, 1210 .. 7000$



Calculate count rate in various spectral bands:

$$\int_{1200}^{3000} \Phi(\lambda)\cdot A(\lambda)\,d\lambda = 1.3\cdot 10^{-3}$$ ct s^{-1}

$$\int_{3000}^{4000} \Phi(\lambda)\cdot A(\lambda)\,d\lambda = 1.0\cdot 10^{-7}$$ ct s^{-1}

$$\int_{4000}^{7000} \Phi(\lambda)\cdot A(\lambda)\,d\lambda = 2.0\cdot 10^{-6}$$ ct s^{-1}

$$\int_{1200}^{7000} \Phi(\lambda)\cdot A(\lambda)\,d\lambda = 1.3\cdot 10^{-3}$$ ct s^{-1}

Note: ROSAT HRI count rate: 0.1960 ct s^{-1}

Vega (A0 V star; U=0.02 B=0.03 V=0.03)

$ORIGIN := 0$

Importing the star's spectrum:

$b\_spectrum := READPRN("vegaspect.prn")$

$wavel := b\_spectrum^{\langle 0\rangle}$ A

$intensity := b\_spectrum^{\langle 1\rangle}$ erg s^{-1} cm^{-2} A^{-1}

Linear interpolation to create a continuous intensity function:

$I(\lambda) := linterp(wavel, intensity, \lambda)$

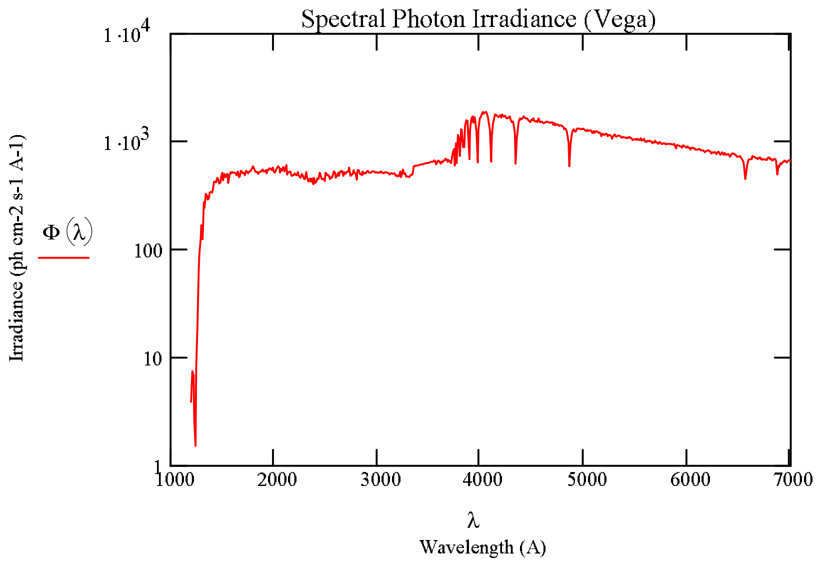
with $h := 6.6261 \cdot 10^{-27}$ erg s $c := 2.998 \cdot 10^{10}$ cm s^{-1}

the photon irradiance is given by

$$\Phi(\lambda) := I(\lambda) \cdot \left(\frac{\lambda \cdot 10^{-8}}{h \cdot c}\right)$$ photons cm^{-2} s^{-1} A^{-1}

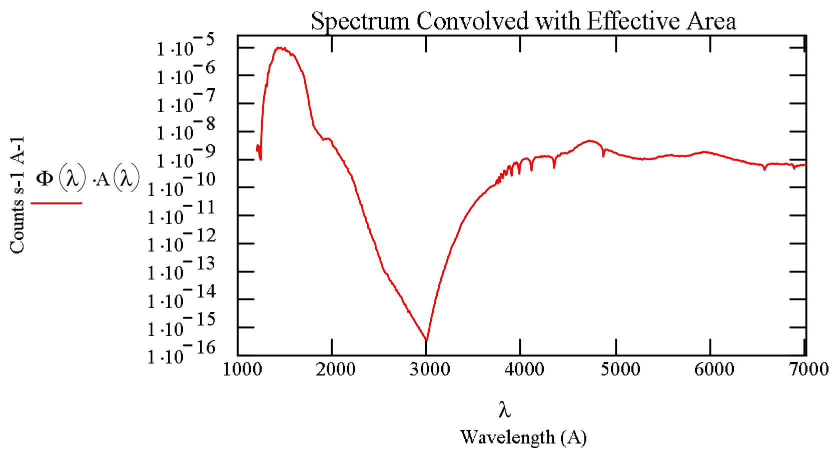
A plot of the spectral photon irradiance:

$\lambda := 1200, 1210 .. 7000$



Effective area model convolved with stellar spectrum to obtain count rate:

$\lambda := 1200, 1210 .. 7000$



Calculate count rate in various spectral bands:

$$\int_{1200}^{3000} \Phi(\lambda)\cdot A(\lambda)\,d\lambda = 8.4\cdot 10^{-4} \qquad \text{ct s}^{-1}$$

$$\int_{3000}^{4000} \Phi(\lambda)\cdot A(\lambda)\,d\lambda = 7.7\cdot 10^{-8} \qquad \text{ct s}^{-1}$$

$$\int_{4000}^{7000} \Phi(\lambda)\cdot A(\lambda)\,d\lambda = 2.1\cdot 10^{-6} \qquad \text{ct s}^{-1}$$

$$\int_{1200}^{7000} \Phi(\lambda)\cdot A(\lambda)\,d\lambda = 8.0\cdot 10^{-4} \qquad \text{ct s}^{-1}$$

Note: ROSAT HRI count rate: 0.0937 ct s^{-1}

Zeta Aquilae (A0 V star; U=2.99 B=3.00 V=2.99)

$ORIGIN := 0$

Importing the star's spectrum:

b_spectrum := READPRN("zetaaqlspect.prn")

$wavel := b\_spectrum^{\langle 0 \rangle}$ A

$intensity := b\_spectrum^{\langle 1 \rangle}$ erg s^{-1} cm^{-2} A^{-1}

Linear interpolation to create a continuous intensity function:

$I(\lambda) := linterp(wavel, intensity, \lambda)$

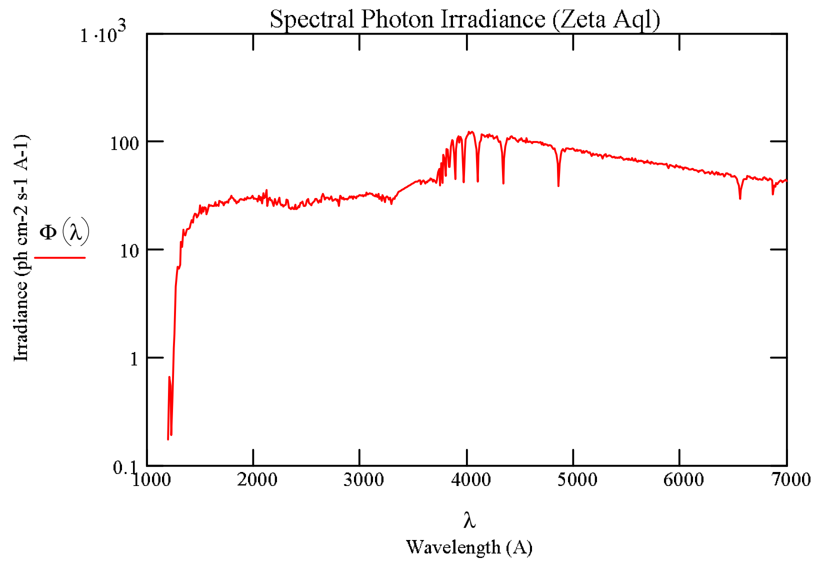
with $h := 6.6261 \cdot 10^{-27}$ erg s $c := 2.998 \cdot 10^{10}$ cm s^{-1}

the photon irradiance is given by

$$\Phi(\lambda) := I(\lambda) \cdot \left(\frac{\lambda \cdot 10^{-8}}{h \cdot c} \right)$$

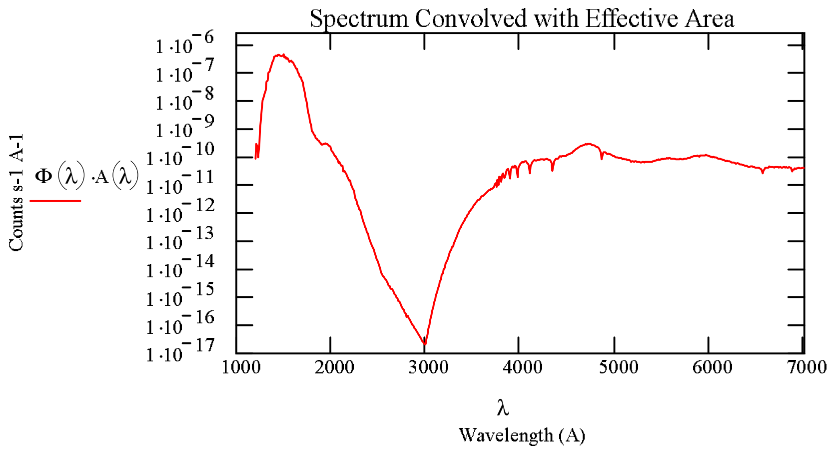
photons cm^{-2} s^{-1} A^{-1}

A plot of the spectral photon irradiance: $\lambda := 1200, 1210 .. 7000$



Effective area model convolved with stellar spectrum to obtain count rate:

$\lambda := 1200, 1210 .. 7000$



Calculate count rate in various spectral bands:

$$\int_{1200}^{3000} \Phi(\lambda)\cdot A(\lambda)\,d\lambda = 4.0\cdot 10^{-5}$$ ct s^{-1}

$$\int_{3000}^{4000} \Phi(\lambda)\cdot A(\lambda)\,d\lambda = 5.0\cdot 10^{-9}$$ ct s^{-1}

$$\int_{4000}^{7000} \Phi(\lambda)\cdot A(\lambda)\,d\lambda = 1.4\cdot 10^{-7}$$ ct s^{-1}

$$\int_{1200}^{7000} \Phi(\lambda)\cdot A(\lambda)\,d\lambda = 4.0\cdot 10^{-5}$$ ct s^{-1}

Note: ROSAT HRI count rate: <0.0042 ct s^{-1}

In summary:

Source	HRC predicted rate (ct s-1)	ROSAT HRI rate (ct s^{-1})	HRC/HRI
betelgeuse	1.3e-06	< 5e-04	
beta aur	3.0e-05	7.8e-03	0.004
beta car	7.8e-05	1.11e-02	0.007
rigel	1.2e-03	1.96e-01	0.006
vega	7.4e-04	9.37e-02	0.008
zeta aql	3.7e-05	< 4.2e-03	
A0,V=-1.5 (T=10800 K)	1.9e-03		

a