157 notes on M51 science

Using Magnitudes

Consider two stars, one of which is a hundred times fainter than the other in some waveband (say *V*).

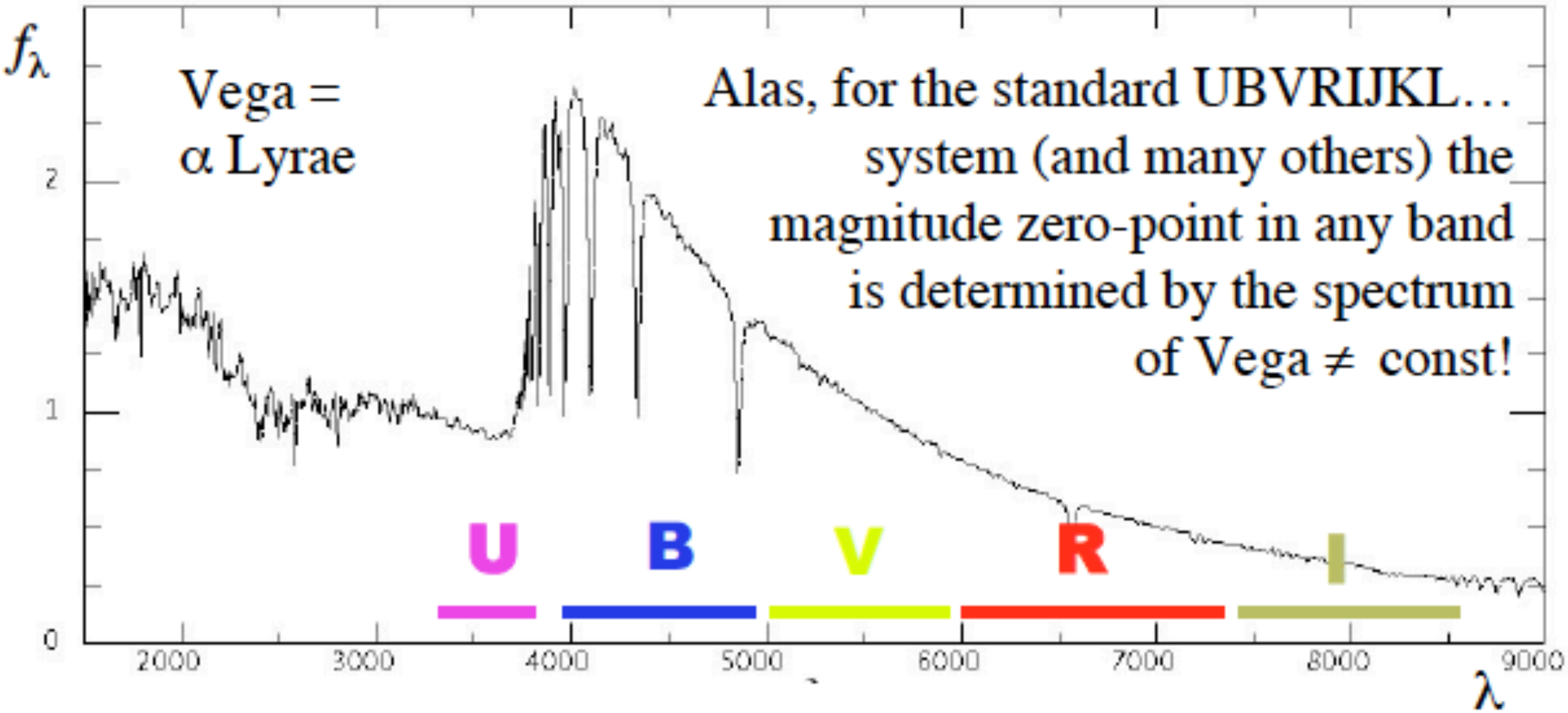
$$m_1 = -2.5\log F_1 + \text{constant}$$

$$\begin{aligned} m_2 &= -2.5\log(0.01F_1) + \text{constant} \\ &= -2.5\log(0.01) - 2.5\log F_1 + \text{constant} \\ &= 5 - 2.5\log F_1 + \text{constant} \\ &= 5 + m_1 \end{aligned}$$

Source that is 100 times **fainter** in flux is five magnitudes fainter (**larger** number).

Faintest objects detectable with *HST* have magnitudes of ~ 28 in R/I bands. The sun has m_V = -26.75 mag

Magnitude Zero Points



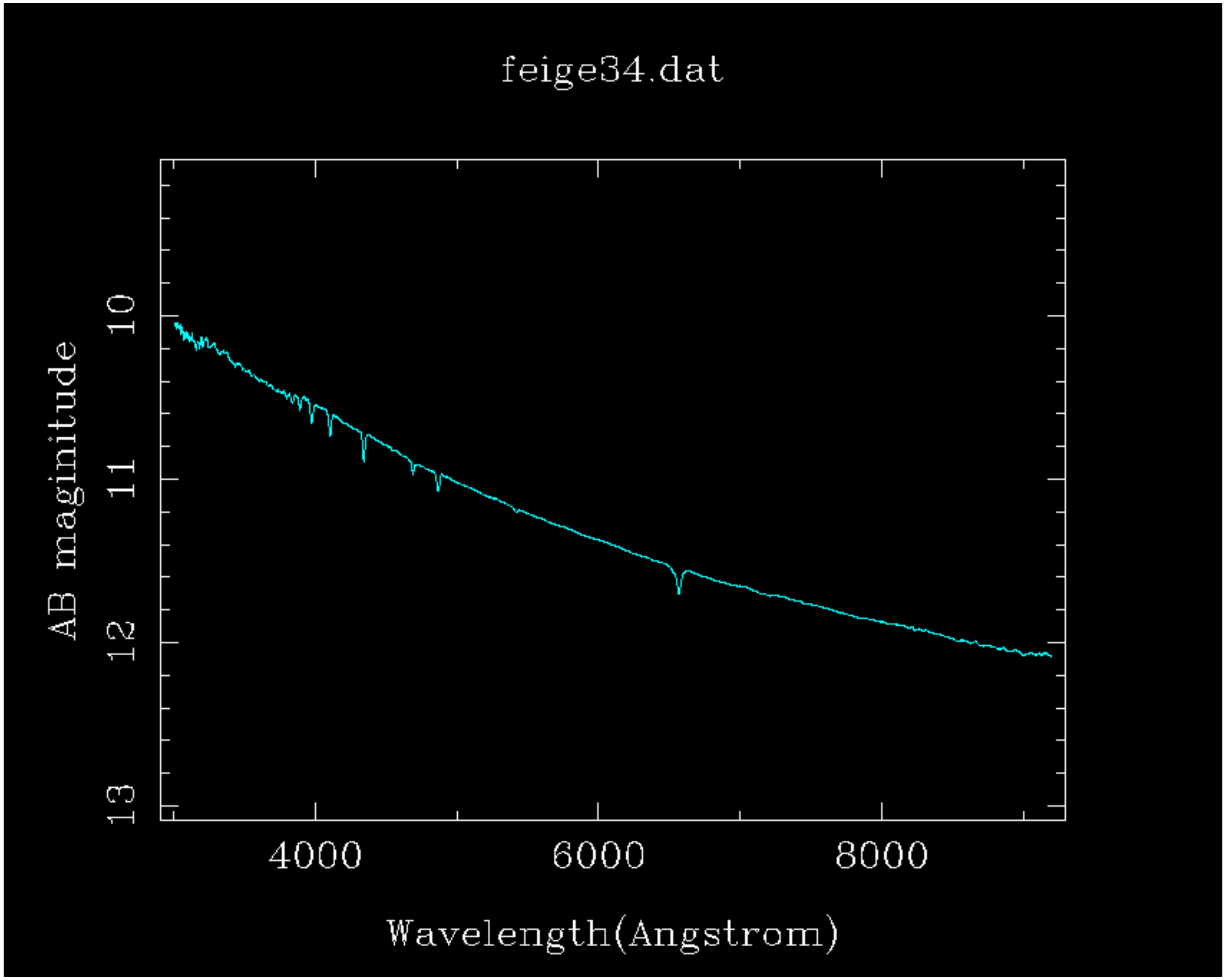
Vega calibration ($m = 0$): at $\lambda = 5556$: $f_\lambda = 3.39 \times 10^{-9}$ erg/cm²/s/Å

$f_\nu = 3.50 \times 10^{-20}$ erg/cm²/s/Hz

$N_\lambda = 948$ photons/cm²/s/Å

A more logical system is AB_ν magnitudes:

$$AB_\nu = -2.5 \log f_\nu \text{ [cgs]} - 48.60$$


feige34.dat
AB maginitude
10
11
12
13
4000
6000
8000
Wavelength(Angstrom)

Apparent vs. Absolute Magnitudes

The absolute magnitude is defined as the apparent mag. a source would have if it were at a distance of 10 pc:

$$M = m + 5 - 5 \log d/\mathrm{pc}$$

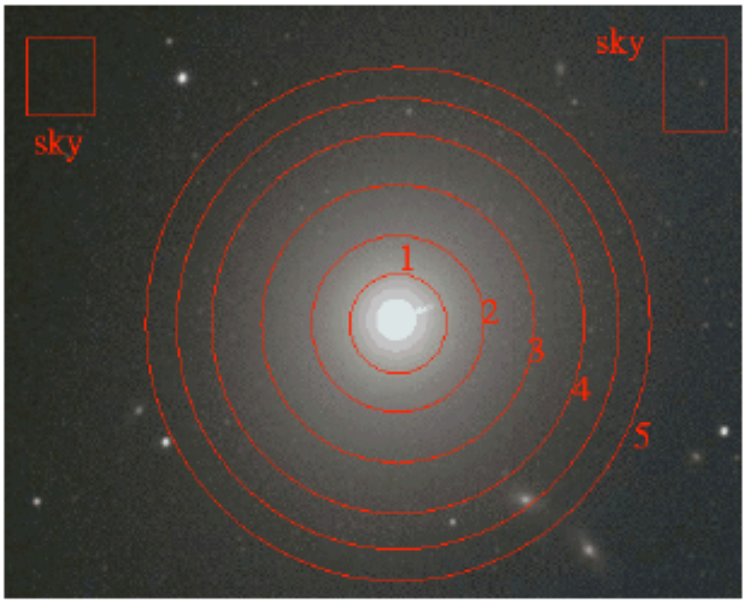
It is a measure of the **luminosity** in some waveband.
For Sun: $M_{\odot B} = 5.47$, $M_{\odot V} = 4.82$, $M_{\odot bol} = 4.74$

Difference between the apparent magnitude m and the absolute magnitude M (any band) is a ***measure of the distance*** to the source

$$\underbrace{m - M}_{\text{Distance modulus}} = 5 \log_{10}\left(\frac{d}{10\ \mathrm{pc}}\right)$$

Distance modulus

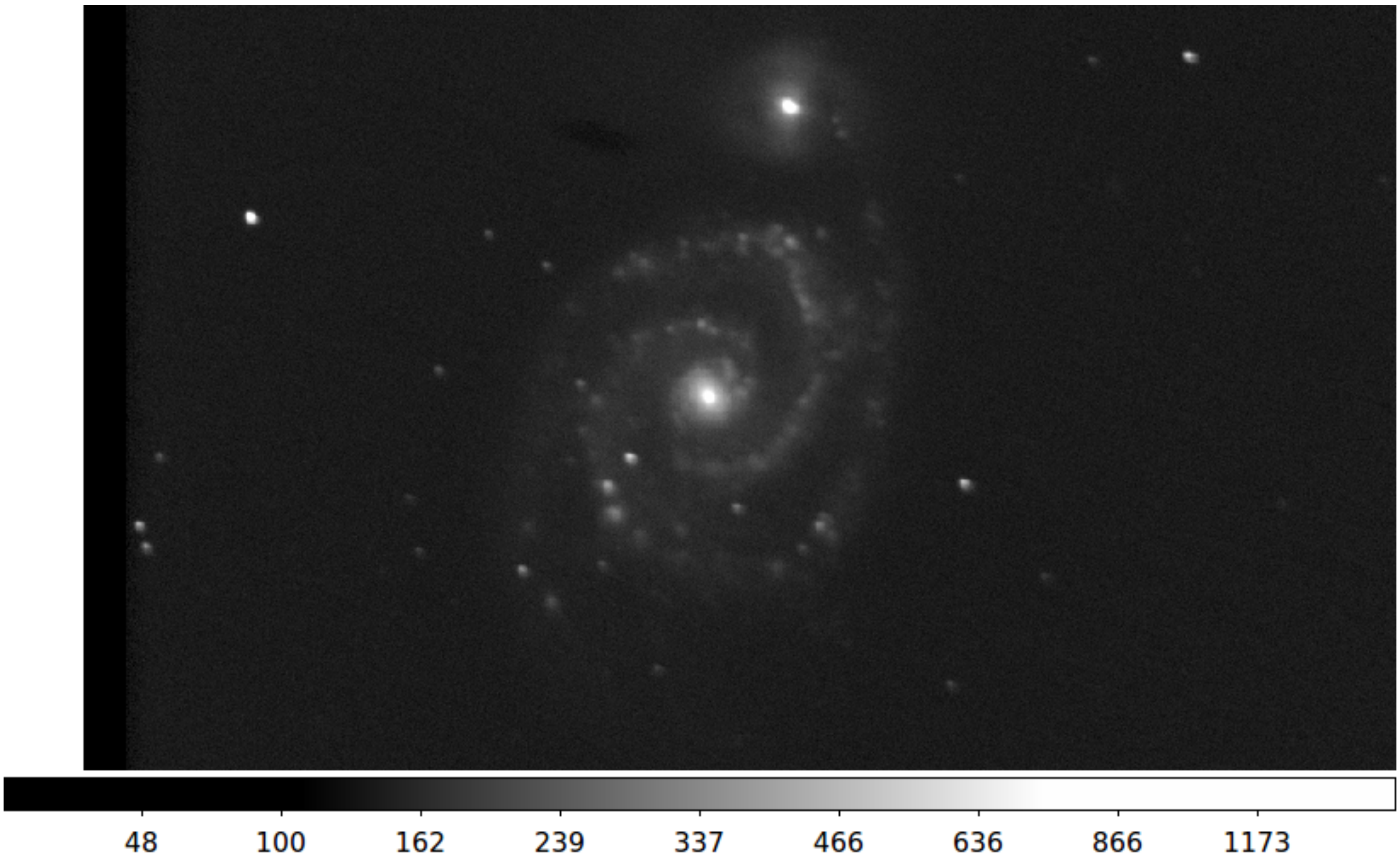
Surface Photometry



Simple approach of aperture photometry works OK for some purposes.

$$mag = c_0 - 2.5(cnts_{aper} - \pi r^2 sky)$$

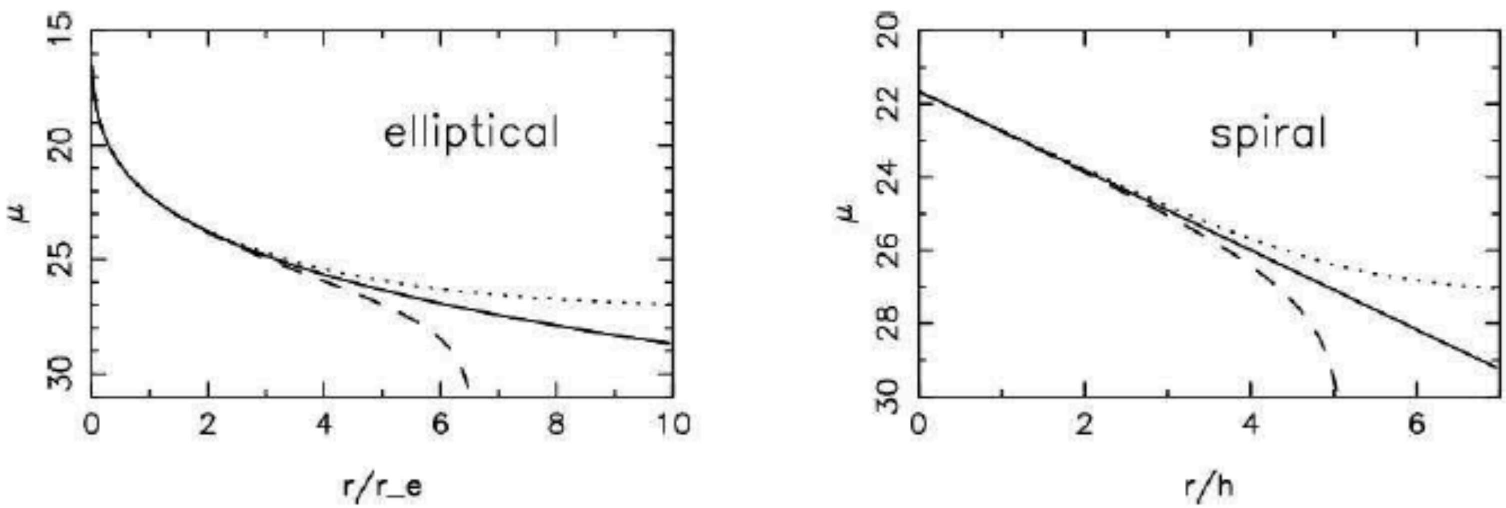
Typically working with much larger apertures
- prone to contamination
- sky determination even more critical
- often want to know more than total brightness



48
100
162
239
337
466
636
866
1173

Sky background subtraction

Inaccurate subtraction of the background contribution can mislead the following interpretation.



The effects of errors in the subtracted sky level on the typical profiles of E and S galaxies (*dashed line* – the background was overestimated by 1%, *dotted line* – underestimated by 1%).

Kennicutt 1998

2.3 *Recombination Lines*

Figure 1 shows that the most dramatic change in the integrated spectrum with galaxy type is a rapid increase in the strengths of the nebular emission lines. The nebular lines effectively re-emit the integrated stellar luminosity of galaxies shortward of the Lyman limit, so they provide a direct, sensitive probe of the young massive stellar population. Most applications of this method have been based on measurements of the Hα line, but other recombination lines including Hβ, Pα, Pβ, Brα, and Brγ have been used as well.

The conversion factor between ionizing flux and the SFR is usually computed using an evolutionary synthesis model. Only stars with masses >10 $M_{\odot}$ and lifetimes <20 Myr contribute significantly to the integrated ionizing flux, so the emission lines provide a nearly instantaneous measure of the SFR, independent of the previous star formation history. Calibrations have been published by numerous authors, including Kennicutt (1983a), Gallagher et al (1984), Kennicutt et al (1994), Leitherer & Heckman (1995), and Madau et al (1998). For solar abundances and the same Salpeter IMF (0.1–100 $M_{\odot}$) as was used in deriving equation [1], the calibrations of Kennicutt et al (1994) and Madau et al (1998) yield:

$$\mathrm{SFR}\ (M_{\odot}\ yr^{-1}) = 7.9 \times 10^{-42}\ L(H\alpha)\ (\mathrm{ergs\ s^{-1}}) = 1.08 \times 10^{-53}\ Q(H^0)\ (\mathrm{s^{-1}}). \qquad (2)$$

where $Q(H^0)$ is the ionizing photon luminosity, and the Hα calibration is computed for Case B recombination at T_e = 10000 K. The corresponding conversion factor for $L(\mathrm{Br}\gamma)$ is 8.2×10^{-40} in the same units, and it is straightforward to derive conversions for other recombination lines. Equation 2 yields SFRs that are 7% lower than the widely used calibration of Kennicutt (1983a), with the difference reflecting a combination of updated stellar models and a slightly different IMF (Kennicutt et al 1994). As with other methods, there is a significant variation among published calibrations (~30%), with most of the dispersion reflecting differences in the stellar evolution and atmosphere models.