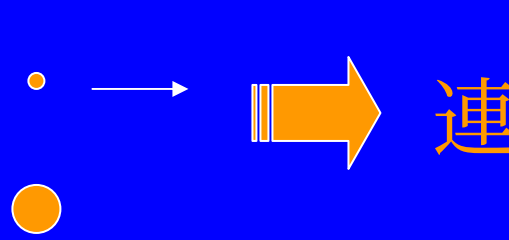
天文資料分析

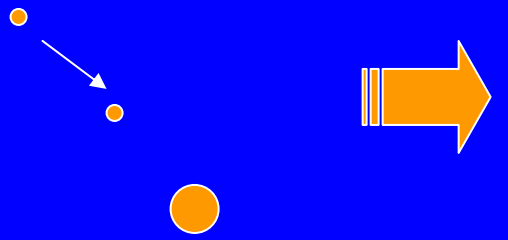
中央大學天文所及物理系
陳文屏
2000.07.13 中央大學暑期天文營

天文觀測 黑暗中找光明、光明中找線索

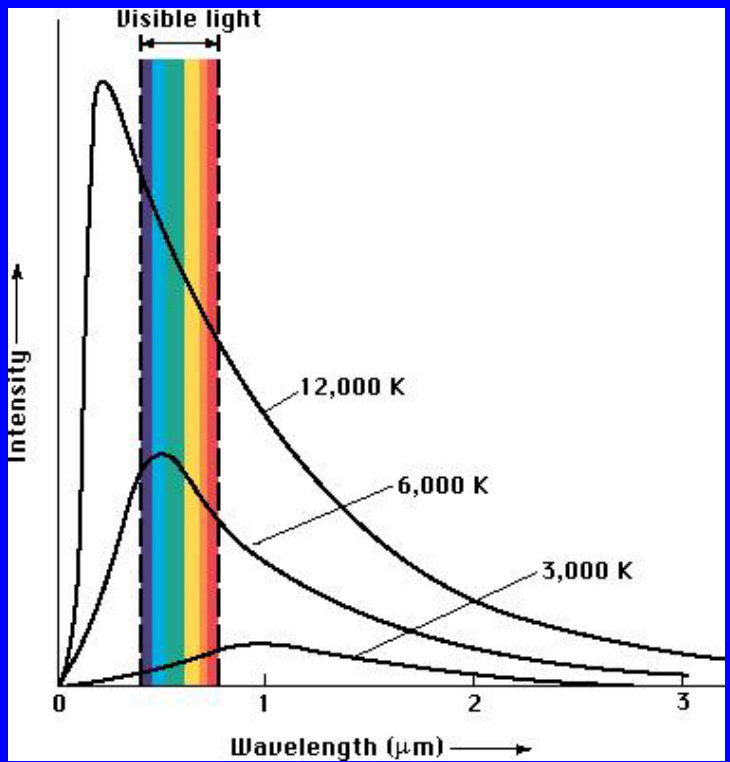
天體、環境 不同的輻射

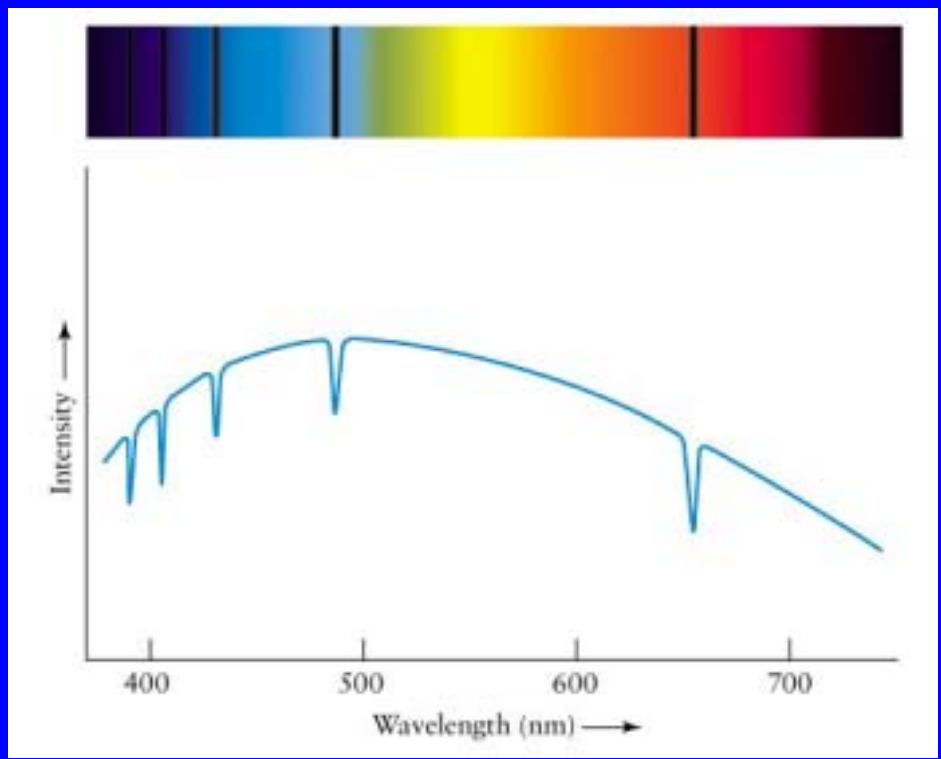


連續譜



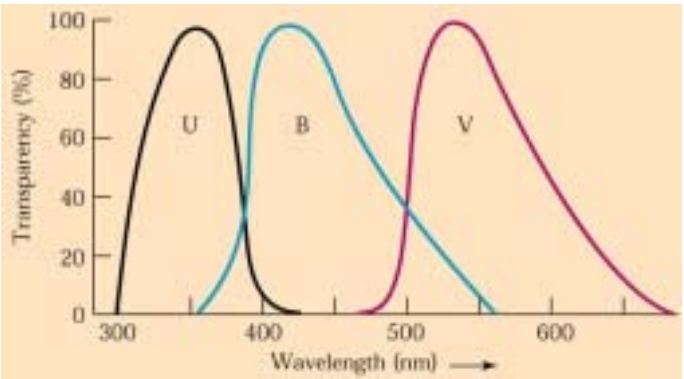
譜線

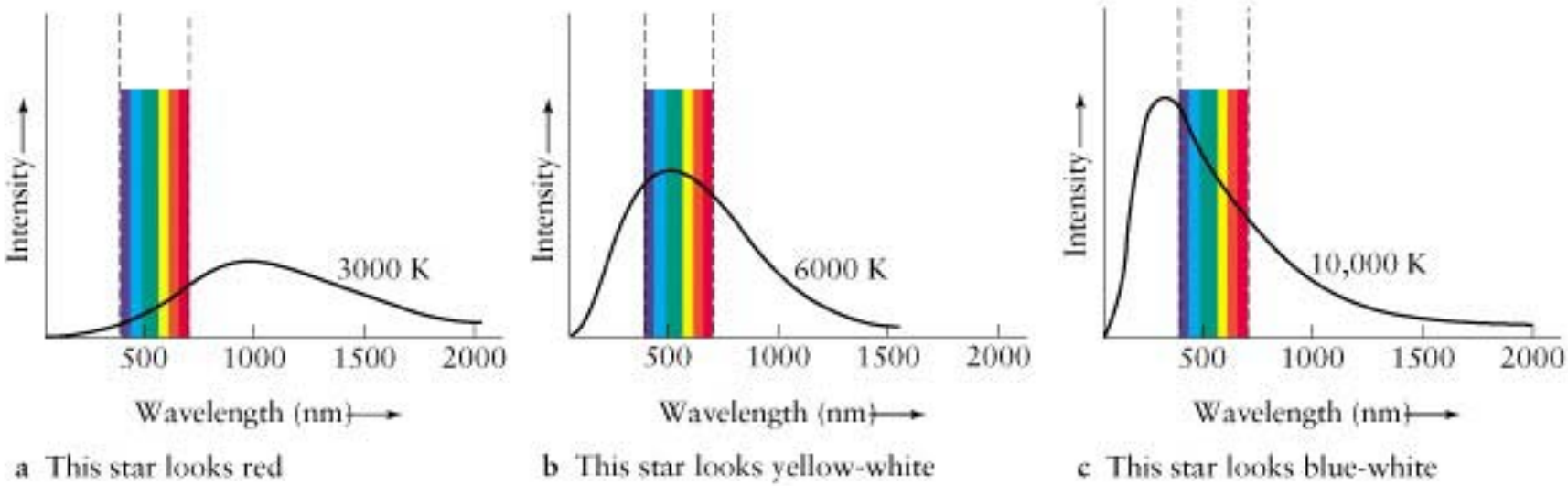




顏色與溫度

越熱的越藍


100
80
60
40
20
0
Transparency (%)
U
B
V
300
400
500
600
Wavelength (nm)


Intensity
3000 K
500
1000
1500
2000
Wavelength (nm)
a This star looks red
Intensity
6000 K
500
1000
1500
2000
Wavelength (nm)
b This star looks yellow-white
Intensity
10,000 K
500
1000
1500
2000
Wavelength (nm)
c This star looks blue-white

天文觀測的手段

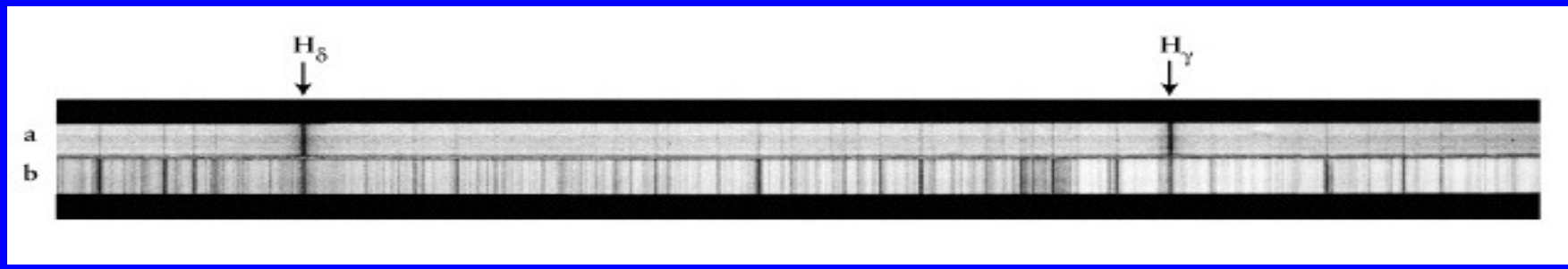
- 光譜觀測 天體發出的電磁波（光）強度隨著波長如何改變
- 光度觀測 天體發出的電磁波有多強——寬波段內所有的光；可視同粗糙的光譜
- 極化、磁場 ……

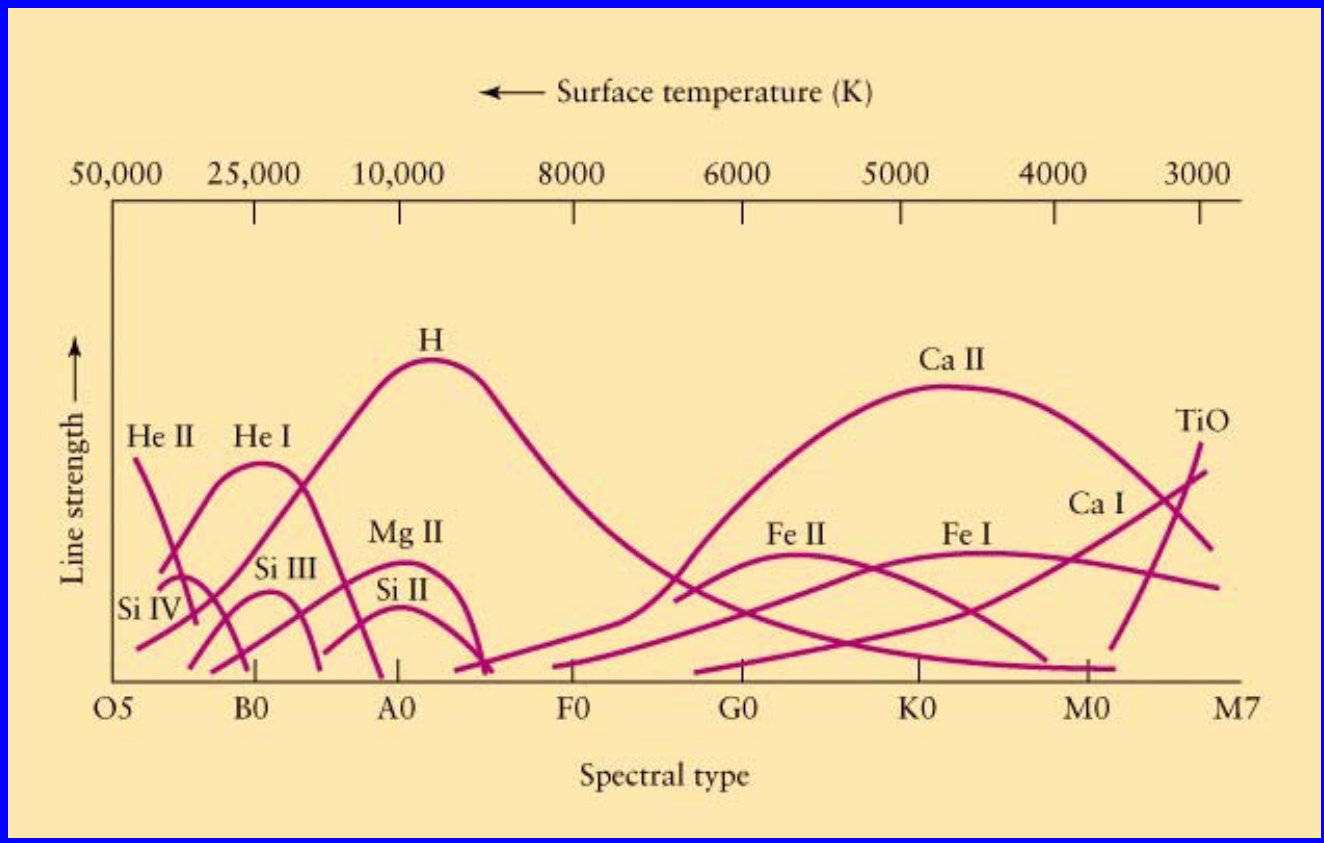
光度測量

- 光度計 —— 單一偵測元件
  天體總共有多亮
  對呀，有多亮呢？(量到的是什麼？)

- **CCD相機 —— 陣列（二維）偵測器**
  (e.g., 512x512; 4096x4096)
  多天體，或延展天體的不同部分
  看到的亮度不等於星體發出的亮度

光譜觀測 隨著波長亮度如何改變



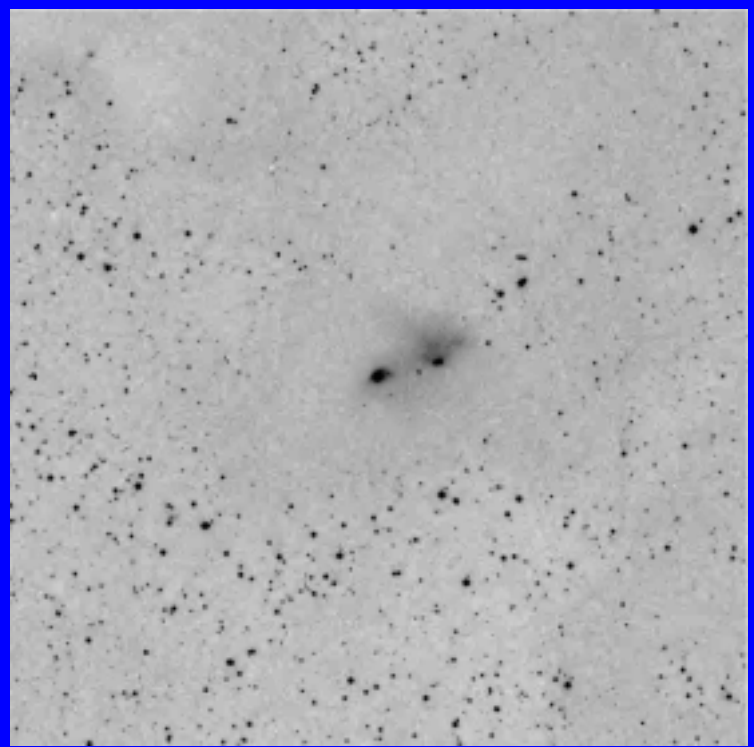


推測化學成分、溫度、壓力、密度、旋轉、磁場等

來自天體的訊號

- 電磁波（光） → 電流、電壓

光電效應



↓

數字 ⟷ 標準星

↓

流量、通量、星等

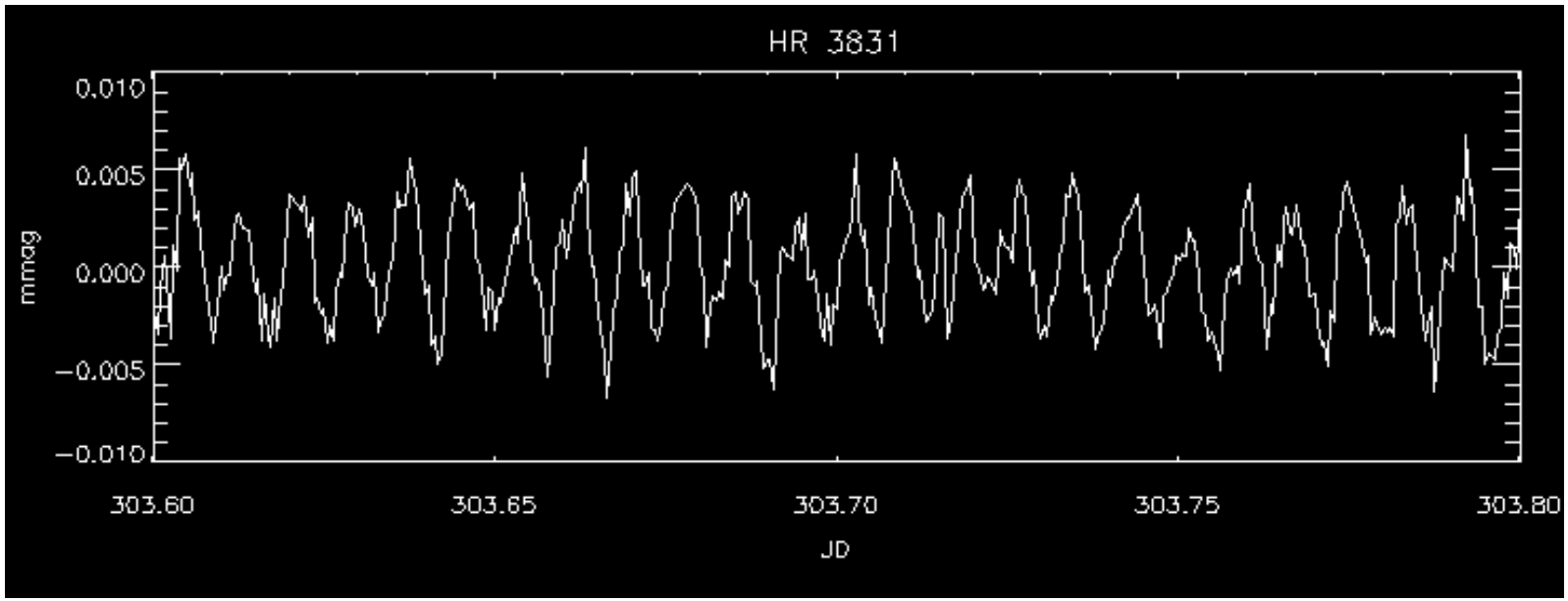
CCD偵測器的優缺點

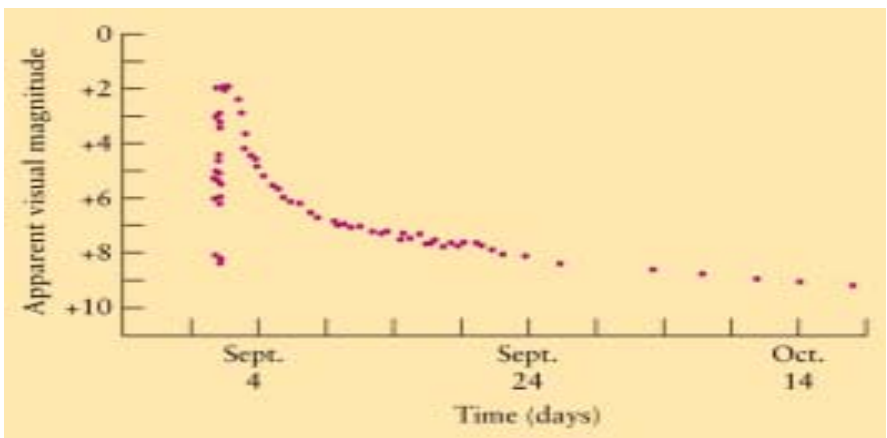
- 成像、效率高
- 每個像元 (pixel) 的靈敏度不一樣，而不同的天體落在不同像元

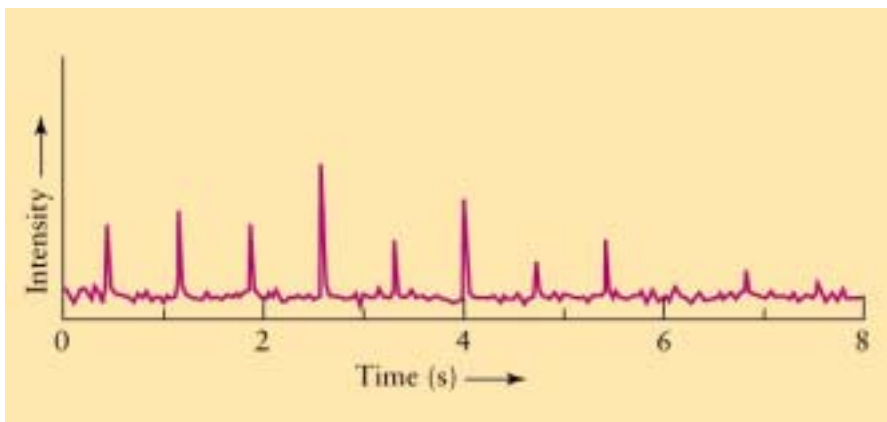
  → 校正各像元的靈敏度

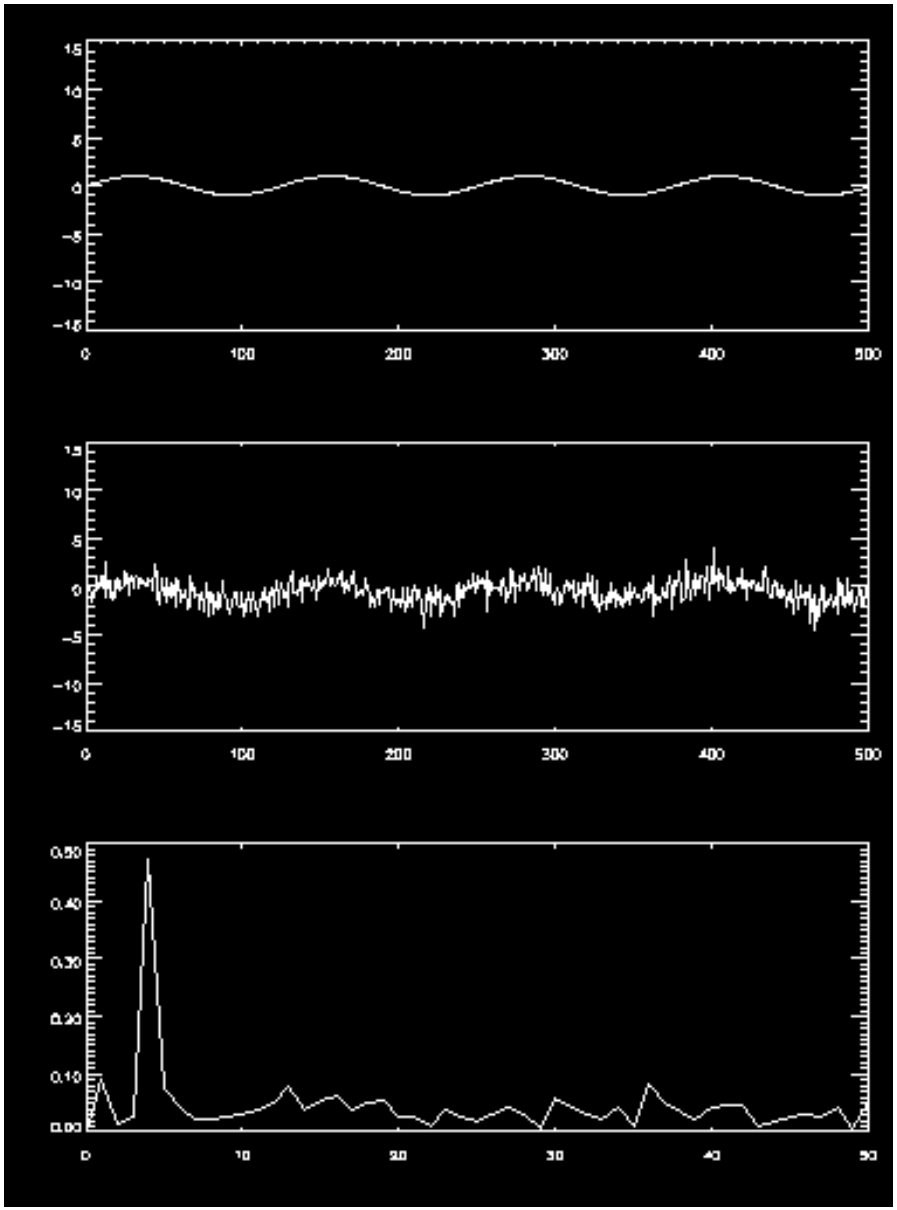
  方法之一：取亮度均勻光源的影像（平場 **flatfield**）
- [原始影像] - [偏壓 bias] - [暗電流 dark]
- 然後除以[平場]

光變曲線—— 光度如何隨時間變化

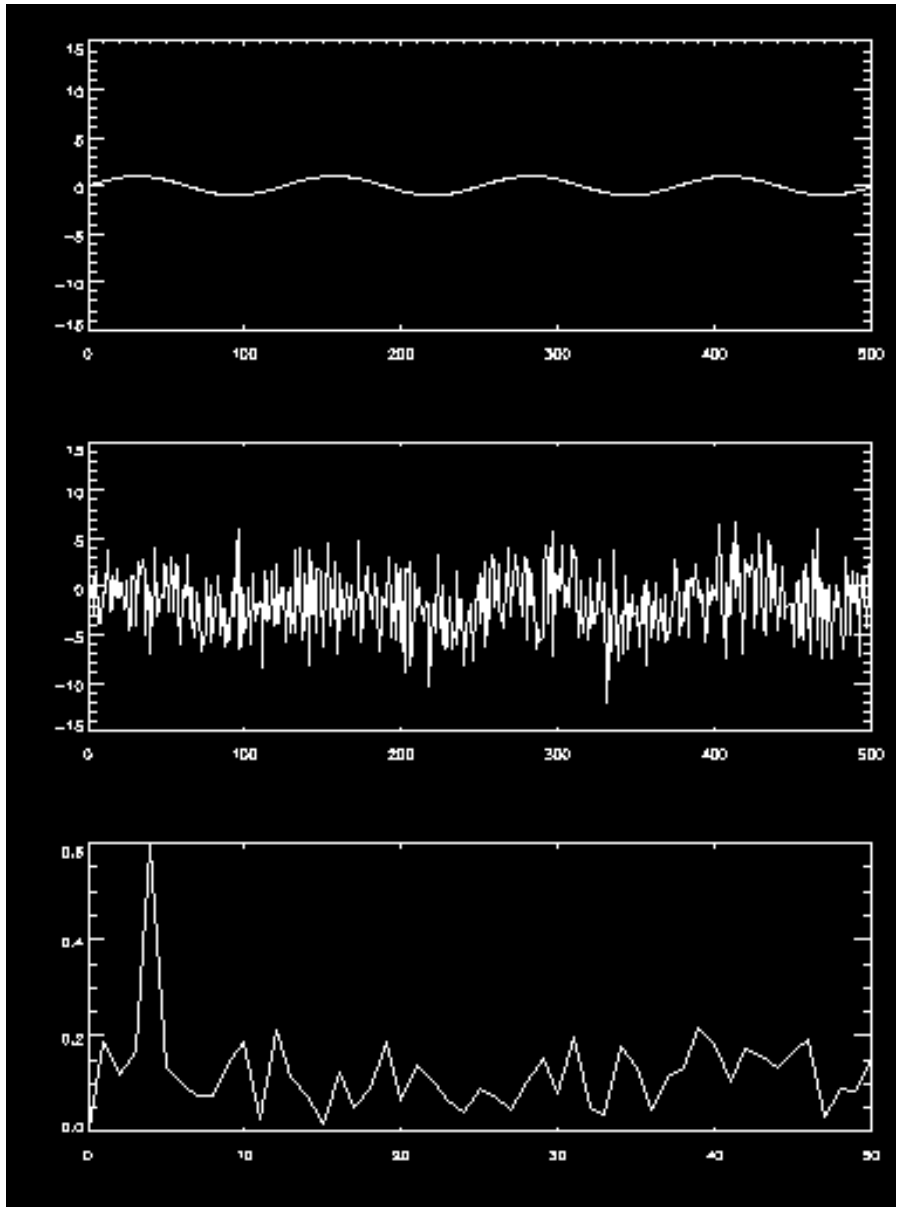






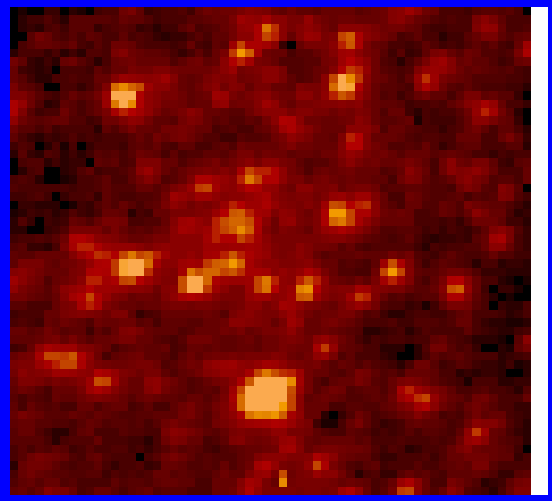


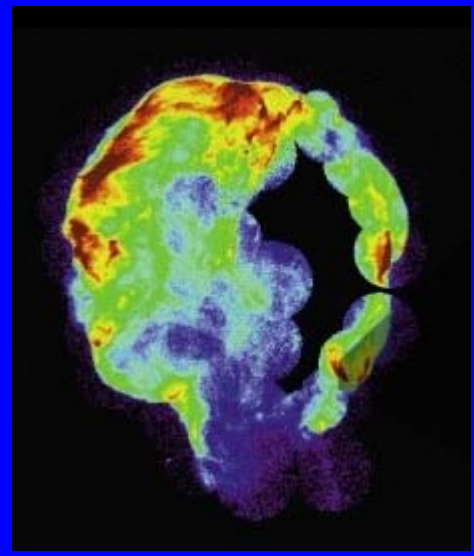
S/N~1



S/N~0.3

在不同波段看不同的東西！





a

b

誤差！誤差！誤差！

- 只有數字沒有單位，或是沒有誤差
  → 完全沒有意義！
- 沒有意義的有效位數
- 大腦＋眼睛＝視覺
  大腦＋耳朵＝聽覺
  大腦＋計算機！

天文資料分析常用軟體 (I)

- **IRAF (Image Reduction and Analysis Facility)**: general-purposed image processing package; cross platforms; script support; flexible memory management; standard package in the astronomy community
- **MIDAS**: European version of IRAF
- **IDL (Interactive Data Language)**: cross-platform language package for data analysis and visualization; wide usage in many disciplines (industrial, medical, scientific)

天文資料分析常用軟體 (II)

- **AIPS**: radio interferometry
- **MIRIAD**: mm data (BIMA specific)

re. FITS (Flexible Image Transport System)

其他相關軟體工具：

(La)Tex, PGPLOT, xv, GhostView, Acrobat Reader, FitsView, ….. etc

Image Restoration

- Imaging equation:

  $r(x) = \int o(x')\ p(x-x')\, dx'$ (convolution)

  or $r = o \otimes p$ p: point-spread function
- In practice, $r = o \otimes p + n$ (1)
- Observe r, calibrate p estimate o
- The high-frequency nature of n makes solving (1) an ill-posed problem.
- Algorithms: CLEAN, Richardson-Lucy, Maximum Entropy