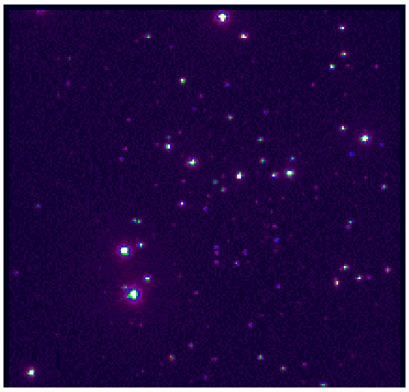
4. THE CCD TECHNIQUE AND DOUBLE STARS

4.1 What is a CCD ?

CCD-Charge Coupled Device

It is a detector based on the technique of photon counting. The CCD chip consists of light sensitive micro-cells called "pixel" (picture element). Each pixel transforms the received photons into charges (e^-). The read out of the CCD is done by a process of charge transfer. The electric signal is then processed by an ADC to produce a digitized image (frame).
The following picture shows you the image CCD of a cluster: it is M16 in the constellation Serpens.



Such an image is used by us to calibrate the scale of the CCD chip.

4.2 AND What about double stars !

With a CCD, we can measure the angular separation between the two components of the double star, their positions and their magnitudes. We simultaneously obtain astrometric and photometric information. We thus study "intermediate" double systems, in other words double systems with angular separation between 1 and 10 arcsec (see table below).

Angular Separation			
Technique	&lt1"	between 1" and 10"	&gt10"
Photoelectric-Photometry	Global information	Global information	information on the components
CCD photometry	Global information	information on the components	information on the components

In astrometry, we can acquire accurate relative positions between two components (with an accuracy of 5% of the pixel width) while in photometry we can measure very accurate differences of intensities between the components (with an accuracy of 1-2%) as well as total intensities.

If you want more information on the topic of CCD's go to: CCD technique (!! very long !!)

4.3 Some results

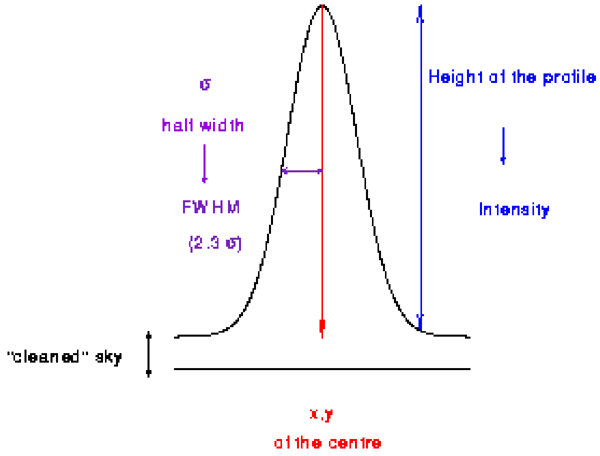


Fig.4.3 – 2-dimensional projection of a 3-dimension profile

The digitized image is sullied by different effects:

- the turbulence (i.e. "smearing")
- photon noise
- thermal noise
- fluctuations from the CCD chip itself

So we have to clean up all these imperfections. Additionally we subtract the sky value from the "target" (double star in our case). This is the first treatment of a raw CCD image. After that, a near-gaussian profile in 3 dimensions is fitted to the digitized image (Lorentz or Moffat profiles are used).
(Cuypers, Proceedings of the International workshop "Visual Double Stars: Formation, Dynamics and Evolutionary Tracks", ASSL Series, 223,1997)

From an astrophysical point of view, the most interesting fitted parameters are (see figure 4.3):

» the position (x,y) of the centre (with an accuracy better than pixel width/20)
» the Full Width Half Maximum (FWHM) (the "smearing" parameter called "seeing")
» the Intensity

These allow us to obtain accurate basic information on the double system e.g:. the relative positions, the magnitude difference . With a good photometric calibration one also has access to the absolute magnitudes of each component.

Example: Star: HIC 112815   Name: -Virginis

We took a set of up to 15 images to improve the data quality. Below the results of the mean for a set consisting of 5 images in the V and 6 images in the I filter are shown:

Measurement Conditions	
Filter	Exposure Time (sec)
Visual	20
Infra-red	10

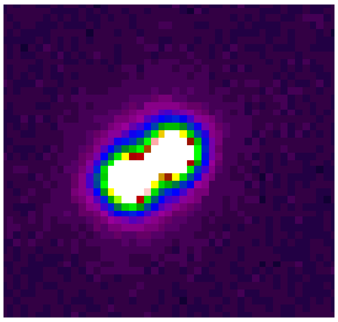


Figure 1-pre-treated image, V filter, t=20sec

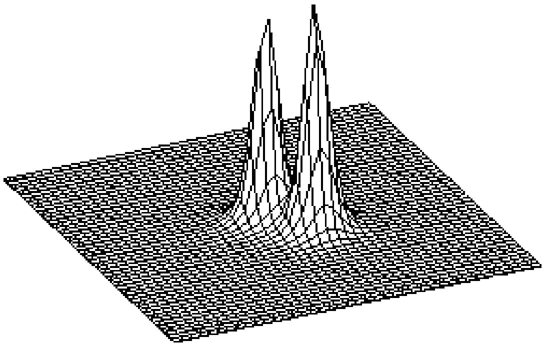


Figure 2-3D Image

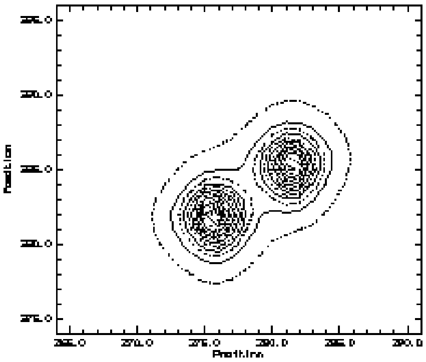


Figure 3-Contour plot showing isophotes of the same double star

<table>
<tr><td colspan="6">CCD-Results for the set of 11 images (I & V)</td></tr>
<tr><td colspan="2">Angular Separation (B w.r.t. A) (Arcsec)</td><td>Positional Angle (B w.r.t. A) (degree)</td><td>Difference of magnitude (V Filter)</td><td colspan="2">Difference of magnitude (I Filter)</td></tr>
<tr><td colspan="2">3.039±0.001</td><td>59.04±0.01</td><td>0.088±0.001</td><td colspan="2">0.079±0.001</td></tr>
<tr><td colspan="6">Comparison with results from the HIPPARCOS MISSION</td></tr>
<tr><td>Angular Separation (Arcsec)</td><td>Positional Angle (B w.r.t. A) (degree)</td><td>Hp magnitude of component A</td><td>Hp magnitude of component B</td><td colspan="2">Difference of Hp magnitudes</td></tr>
<tr><td>3.038±0.014</td><td>59.1</td><td>11.024±0.012</td><td>11.138±0.013</td><td colspan="2">0.11±0.02</td></tr>
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