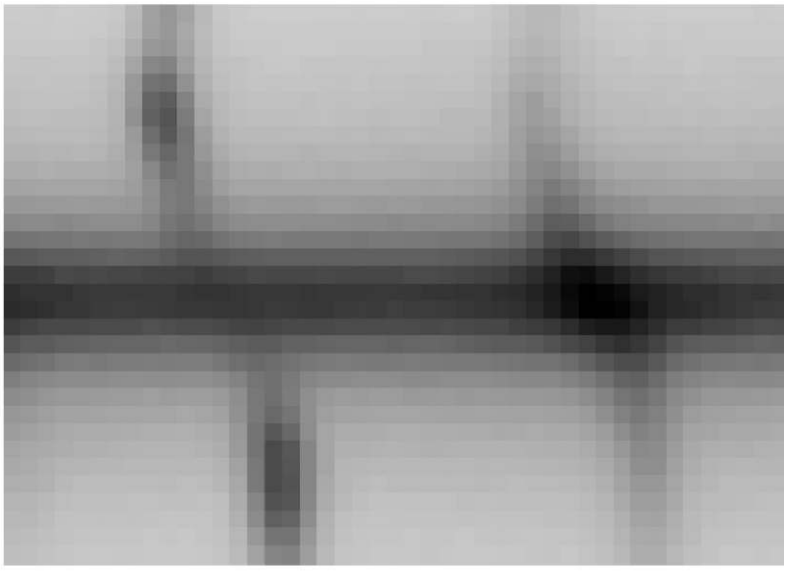
Data Analysis Question 2 - solution



Solution:

$\Delta\lambda = \lambda_1 - \lambda_2 = 20$ Å

distance on picture $=22$ pixels ± 2 > horizontal scale $20/22 = 0.9091$ Å/pixel

Doppler shift from spectrum between upper and lower arm: $\Delta\lambda = 7$ pixels $\pm 1 = 6.3636$ Å

$2V_{radial} = c \cdot \Delta\lambda/\lambda$ ($c \approx 300\,000$ km/s) $= 290.8$ km/s

Inclination problem: (i – angle between line of sight and galactic disc)

Size of galaxy image: $a = 11.5 \pm 0.5$ cm, $b = 6.5 \pm 0.5$ cm > i=arc sin (b/a) $\approx 35^o$

$\cos(i) = V_{radial} / V_{rotation}$ > $V_{rotation} = V_{radial}/2 \cdot \cos(35^o) = 216.7$ km/s

Vertical scale (pixel to distance-from-centre conversion)

For 1 pixel: angle 0.82" corresponds to $2 \cdot 40$ Mpc$\cdot$tg(0.82"/2) = 159 pc in galactic distance

Mass determination:

From Kepler's law: $M = V^2 \cdot R / G$

$R \approx 10$ pixel $= 1590$ pc$\cdot 3.09 \cdot 10^{16}$ m/pc $= 4.9 \cdot 10^{19}$ m

$M = 3.4 \cdot 10^{40}$ kg > $1.7 \cdot 10^{10}\ M_\odot$ ($M_\odot \approx 2 \cdot 10^{30}$ kg)

2. Weighing a galaxy

Max 25 points

estimation of horizontal scale (pixel/Å)	[1]
calculation of $\Delta\lambda$ distance between lines	[1]
calculation of scale in Å/pixel	[1]
estimation of scale error	[1]
Vertical scale	
Calculation of distance from galactic centre or rescaling from "/pixel to pc/pixel	[2]
Estimation of disc inclination based on pictures of galaxy :	
measuring the vertical and horizontal size of galaxy image	[2]
calculating the inclination of galactic disc	[1]
calculating the error of inclination estimation	[1]
estimations of position of line in pixels	[1]
calculations of Doppler shift in Å	[1]
calculations of radial velocity using proper formula and constants	[1]
calculations of velocity for inclination	[1]
proper draw the rotation curve:	
if picture will show: -'solid body' rotation in bulge	[1]
- two arms (blue and read shifted)	[1]
- symmetry between arms	[1]
- more then 10 point per arm	[1]
- fluctuation of "constant level"	[1]
calculation of mass of bulge of galaxy based on Kepler's law	
- using the proper formula	[2]
- using the proper place (end of the bulge) for bulge mass determination	[2]
- estimation of error base of scale and inclination error	[2]