What is the speed of the stars in M51?
Knowing the speed from Kepler's 3rd law
we can determine the mass within the orbit?

d is the distance the star moves over a
time t. Moving with speed v, d =v*t,
v = 100 km/s, t = d/v, time to wait

if deltaA = 1", d = 0.97LY, t = 2906 years
Hipparcos, deltaA = .001", t = 29 years
GAIA, deltaA 20micro.arc.sec, t = 0.116 days

deltaA = 0 ?
V is along the line of sight!
Doppler shift! Light is a wave
phenomenon => a shift in the wave length.

SPECTROSCOPY
What are the wave
lengths of the light
from the bodies.

Along the line of sight we can tell
the speed of the star by the Doppler
shift of the star's wave lengths.

d
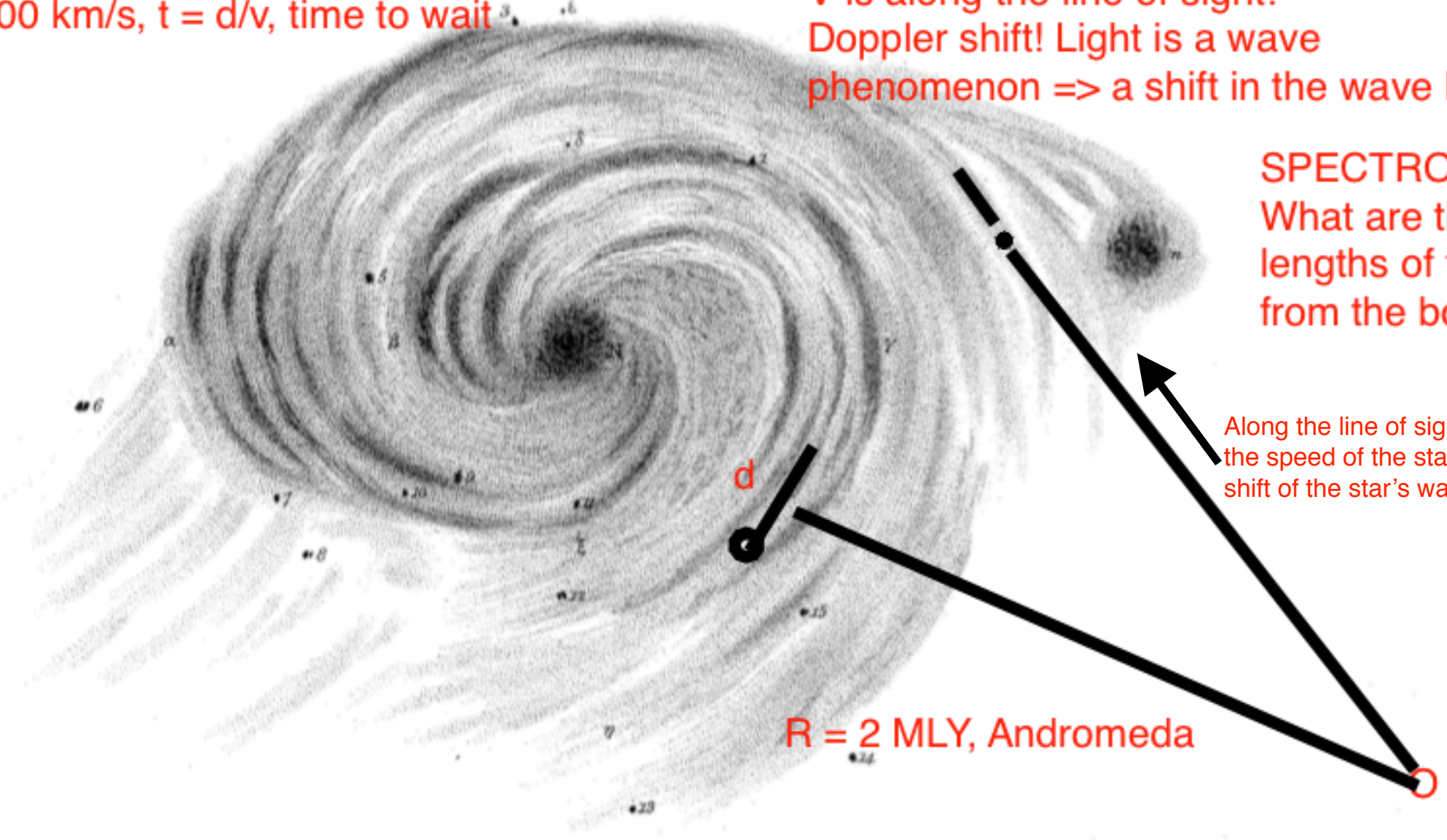
R = 2 MLY, Andromeda

A = d/R, best angle is 1" of arc