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PROBLEM Two RR Lyrae stars have apparent magnitudes 10·81 and 10·82. They are positioned in a nearly straight line radially from Earth. Roughly in between these stars is a cloud of molecular Hydrogen, roughly spherical in shape, 0·00092 radians across in the sky. Assume it is of uniform density, of $n = 10^2/cm^{-3}$ (numerical), $m_H = 1.67 \times 10^{-27}$ kg

(a) Find its mass in solar masses.

(b) The stars are of 0·8 solar mass each. Can they pull apart the cloud?

ANSWERS

(a) To find its mass, we need it's size → we need distance to it first to get diameter from angular size.

Absolute Mag. of RR Lyrae stars ≈ 0·66

⇒ $m_1 = 10.81$, $m_2 = 10.82$ ⇒ $d_1 = 10^{0.2(10.81 - 0.66 + 5)} = 1070$ pc

$d_2 = 10^{0.2(10.82 - 0.66 + 5)} = 1077$ pc

∴ Distance to cloud (D) = $(d_1 + d_2)/2 = 1073.5$ pc

$\theta = 0.00092$ rad ⇒ diameter = (via small angle approx) = $\theta \times D = 0.987$ pc

∴ radius (r) = 0·493 pc $= 1.52 \times 10^{16}$ m

$m_H = 1.67 \times 10^{-27}$ kg → for H_2 ⇒ 3.34×10^{-27} kg

$\rho = n m_{H_2} = 10^2 \times 3.34 \times 10^{-27}$ kg/cm³ ⇒ $10^8 \times 3.34 \times 10^{-27}$ kg/m³

$= 3.34 \times 10^{-19}$ kg/m³

$V = \frac{4}{3}\pi R^3 = 1.47 \times 10^{49}$ m³ (1 pc ≈ 3×10^{16} m)

∴ $M = \rho V = 3.34 \times 10^{30}$

$M_\odot = 1.99 \times 10^{30}$ ⇒ $M = 1.67\, M_\odot$

(b) We need its Binding Energy, and potential energy from 2 stars

if $|B| < PE$ it will pull apart

$B = -\frac{3}{5}\frac{GM^2}{R}$ ⇒ -2.93×10^{34}

P.E. from both stars ⇒

$M = 0.8 + 0.8 = 1.6\ M_\odot$

$R = 3.5\ pc$

$\rightarrow \frac{GMm}{R} = 6.7 \times 10^{33}$

$|B| > PE$

so it's not getting pulled apart