AA 472/672

The Colliding Spiral Galaxies of Arp 271

Galactic and Extragalactic Astronomy.

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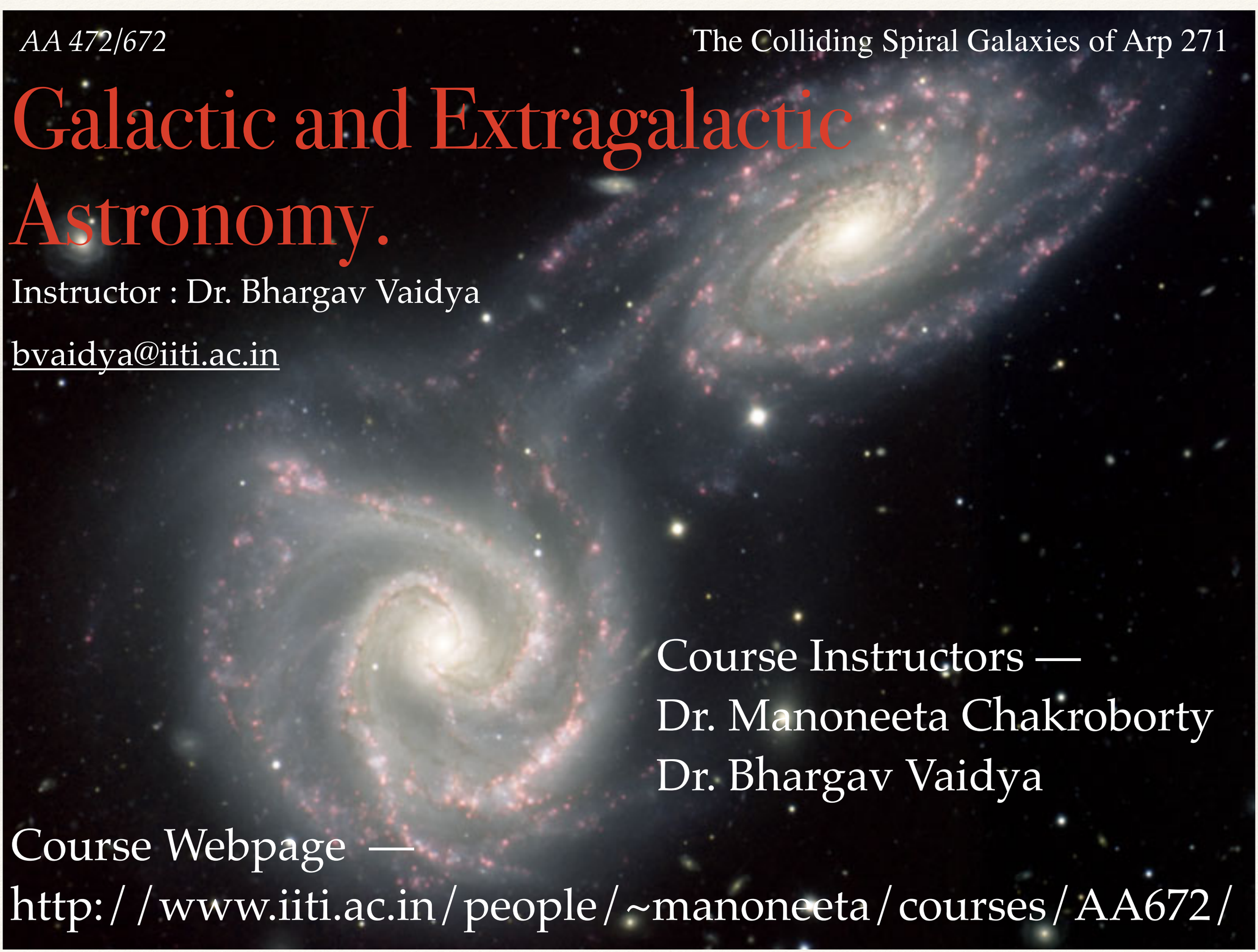

Course Instructors —
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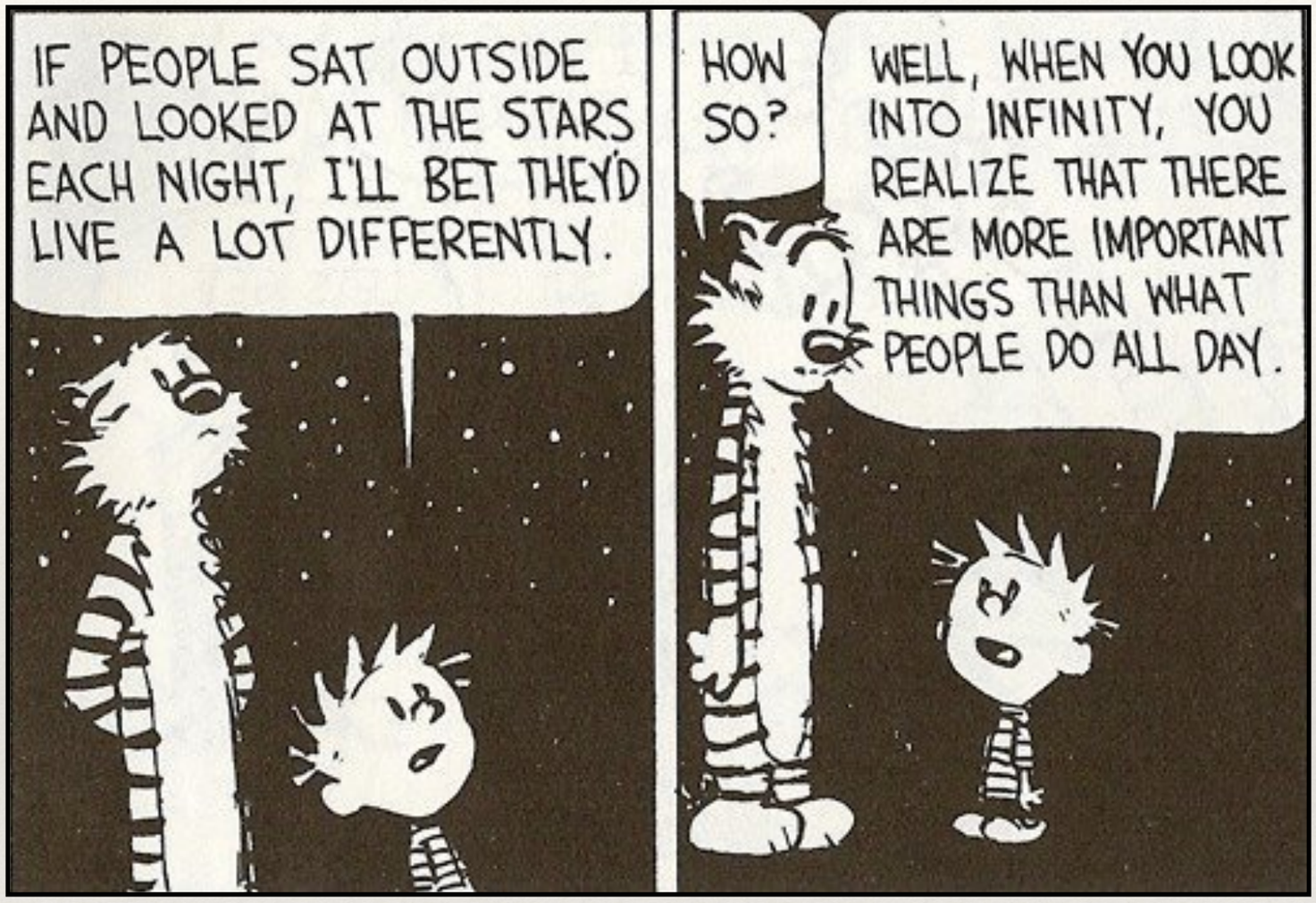
Course Webpage —
http://www.iiti.ac.in/people/~manoneeta/courses/AA672/

Why??

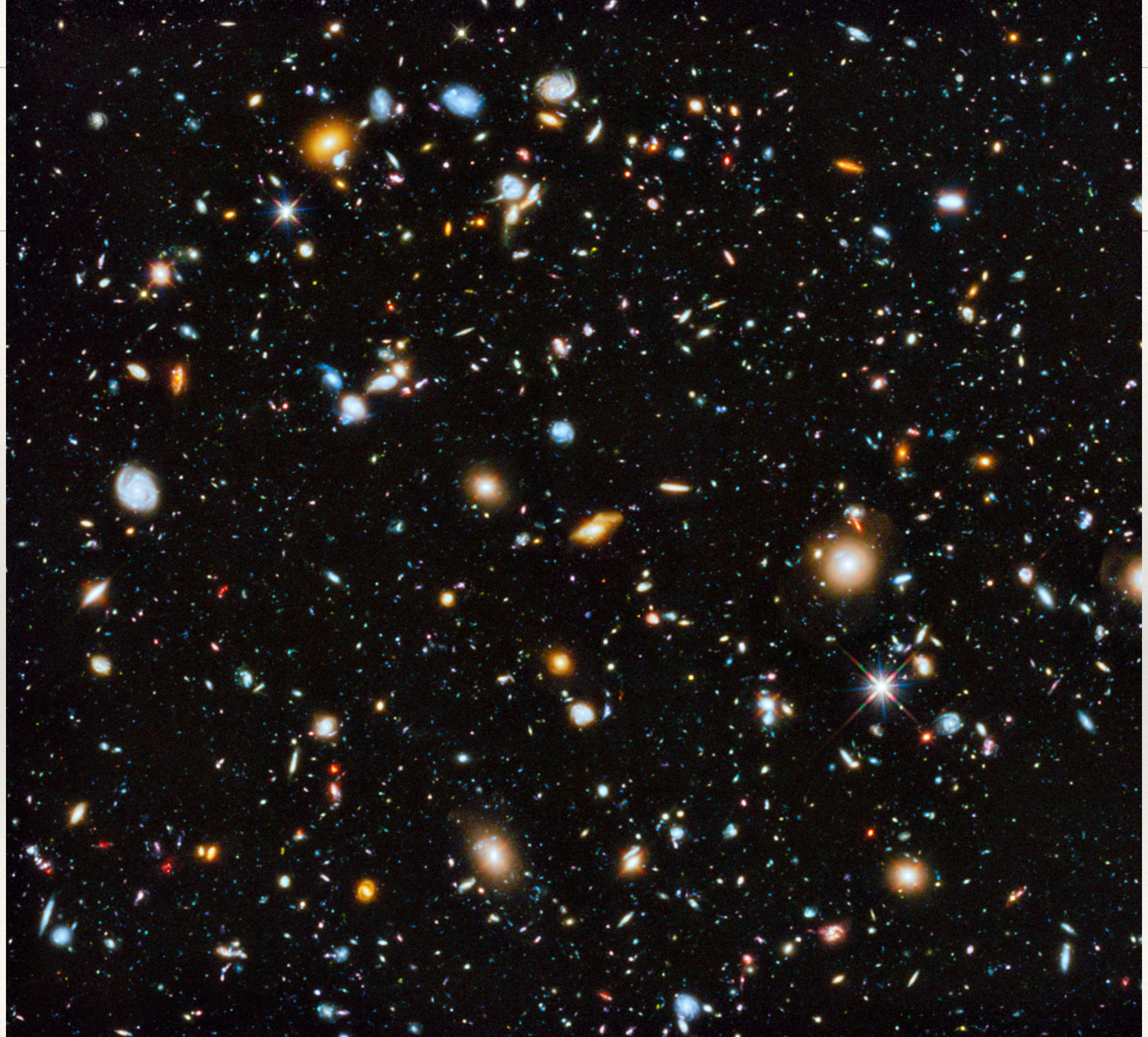


"Space is big. Really big. You just won't believe how vastly hugely mindbogglingly big it is. I mean you may think it's a long way down the road to the chemist's, but that's just peanuts to space."

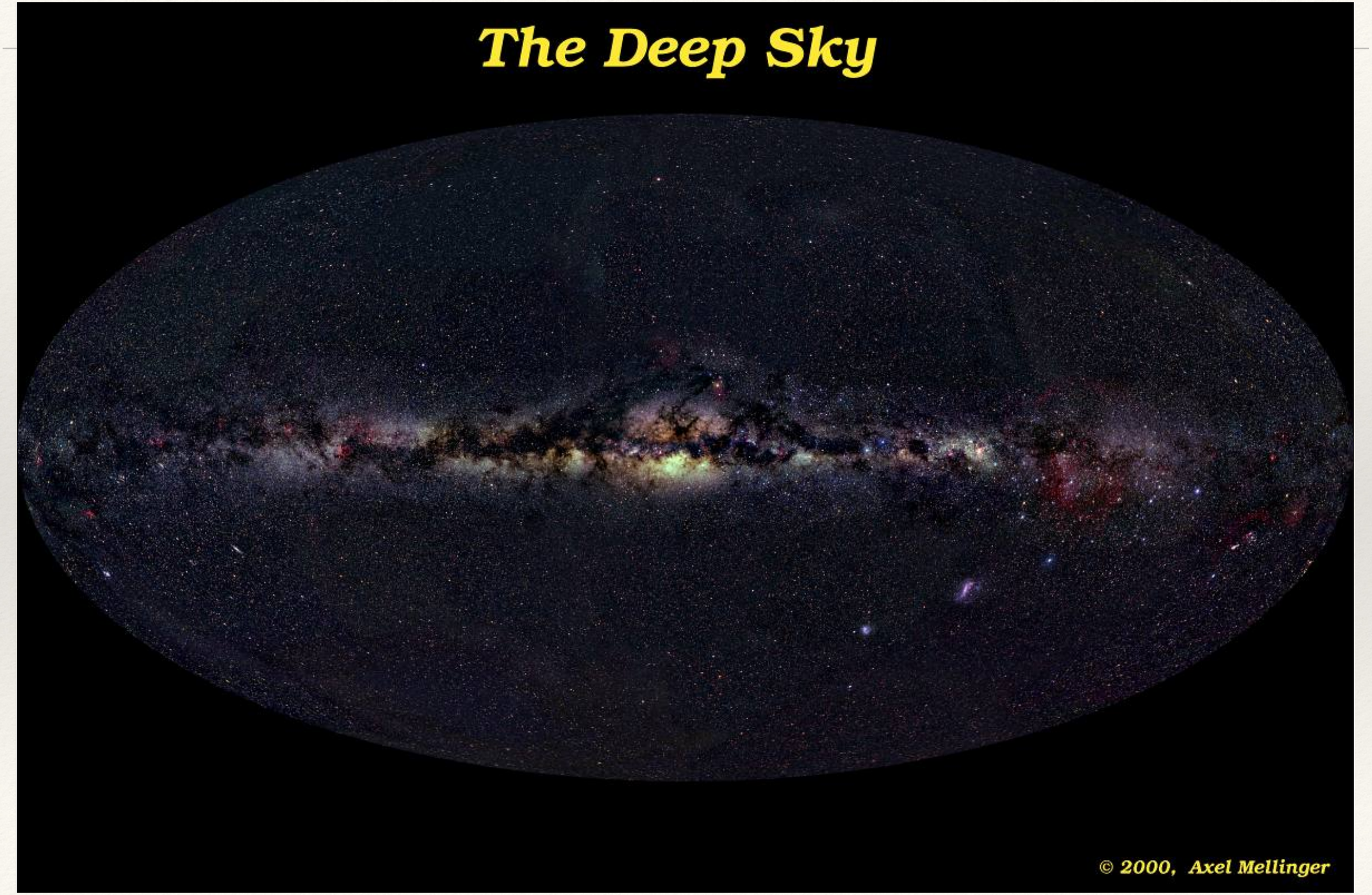
- The Hitchhiker's Guide To The Galaxy

Scope of the course.

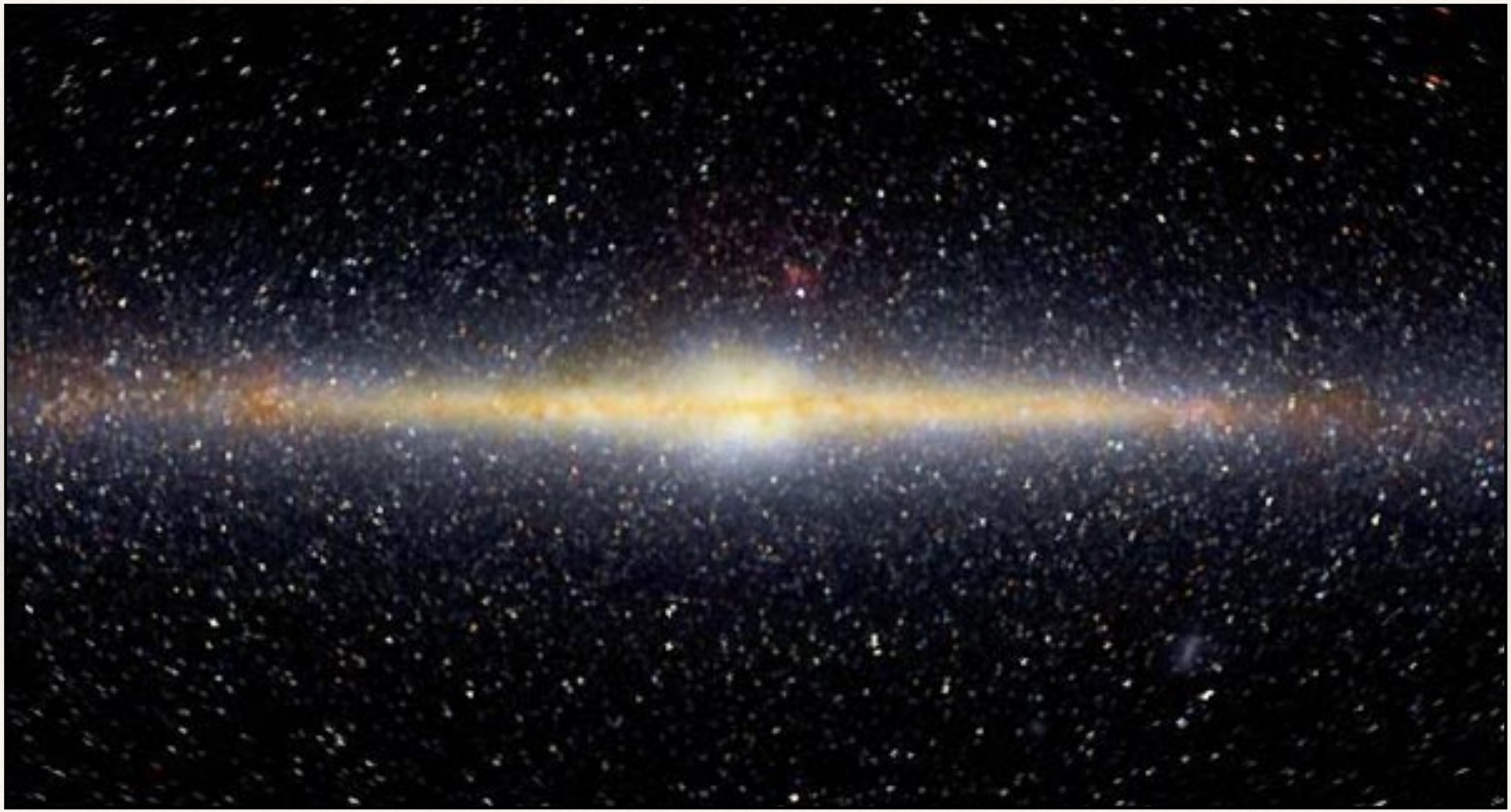
- Objectives:
  - Develop basic knowledge of our own Galaxy, The Milky Way and other galaxies around us.
  - Understand the formation and evolution of galaxies like ours and also those that are very different from Milky Way.
  - Study the various types of Active Galactic Nuclei and its feedback within the host galaxy and in the Inter Galactic medium.
  - Understand the physics of large scale galaxy cluster and associated emission mechanisms.



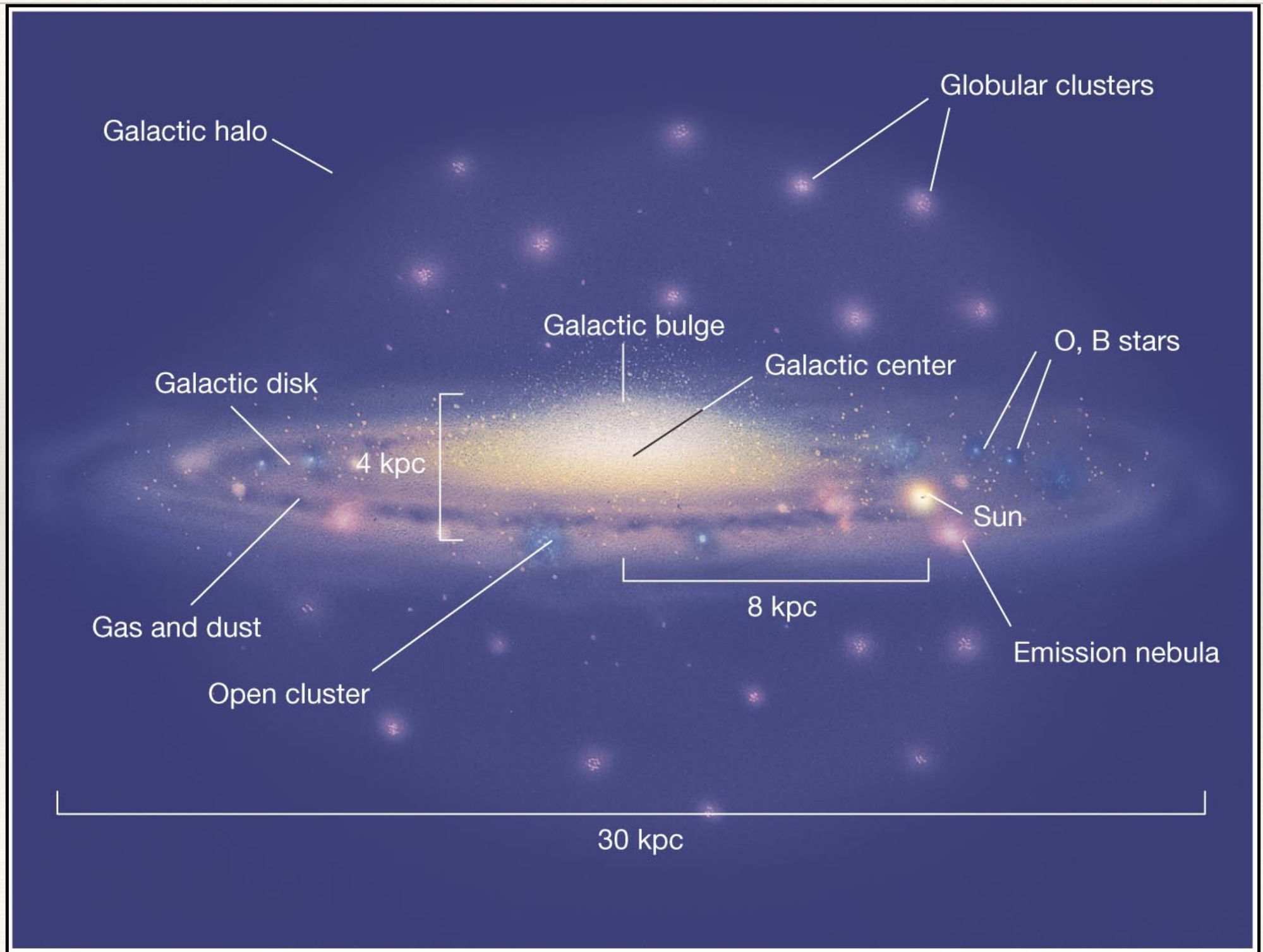
Optical Image.



IR Image



Components Galaxy



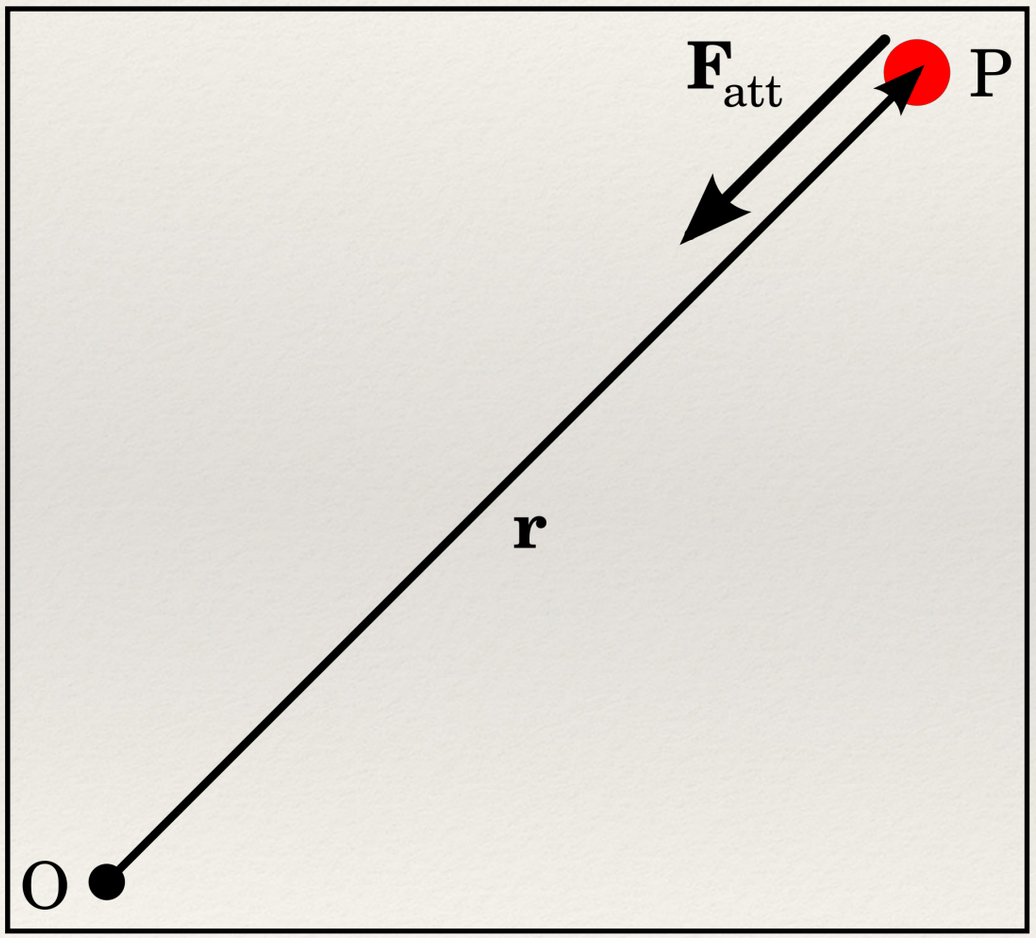
Galactic Dynamics.

- **Preliminaries**
  - *Central Force: Definition, Properties, EoM and examples like motion of stars in spherically symmetric potential.*
- **Galactic Dynamics**
  - Potential Theory - spherical and flattened models , example : Milky Way Components and Potential.
  - Motion of stars in axisymmetric potential
  - Two body system and relaxation Time.

Reference Books.

- *Classical Mechanics* - Herbert Goldstein
- *Galactic Dynamics* - James Binney & Scott Tremaine
- *Extragalactic Astronomy and Cosmology : An Introduction* - Peter Schneider.
- *An Introduction to Modern Astrophysics :* Bradley W Carroll and Dale A Ostlie
- *Galaxy Formation and Evolution* - Houjun Mo, Frank van den Bosch, Simon White
- *Theoretical Astrophysics : Vol. I and Vol. III* - T. Padmanabhan.

Central Force I



- Force acts along the line joining the point P and point O.
- magnitude is a function of radial distance between the two points.

$$|\vec{F}| = F(r)$$

Central Force II.

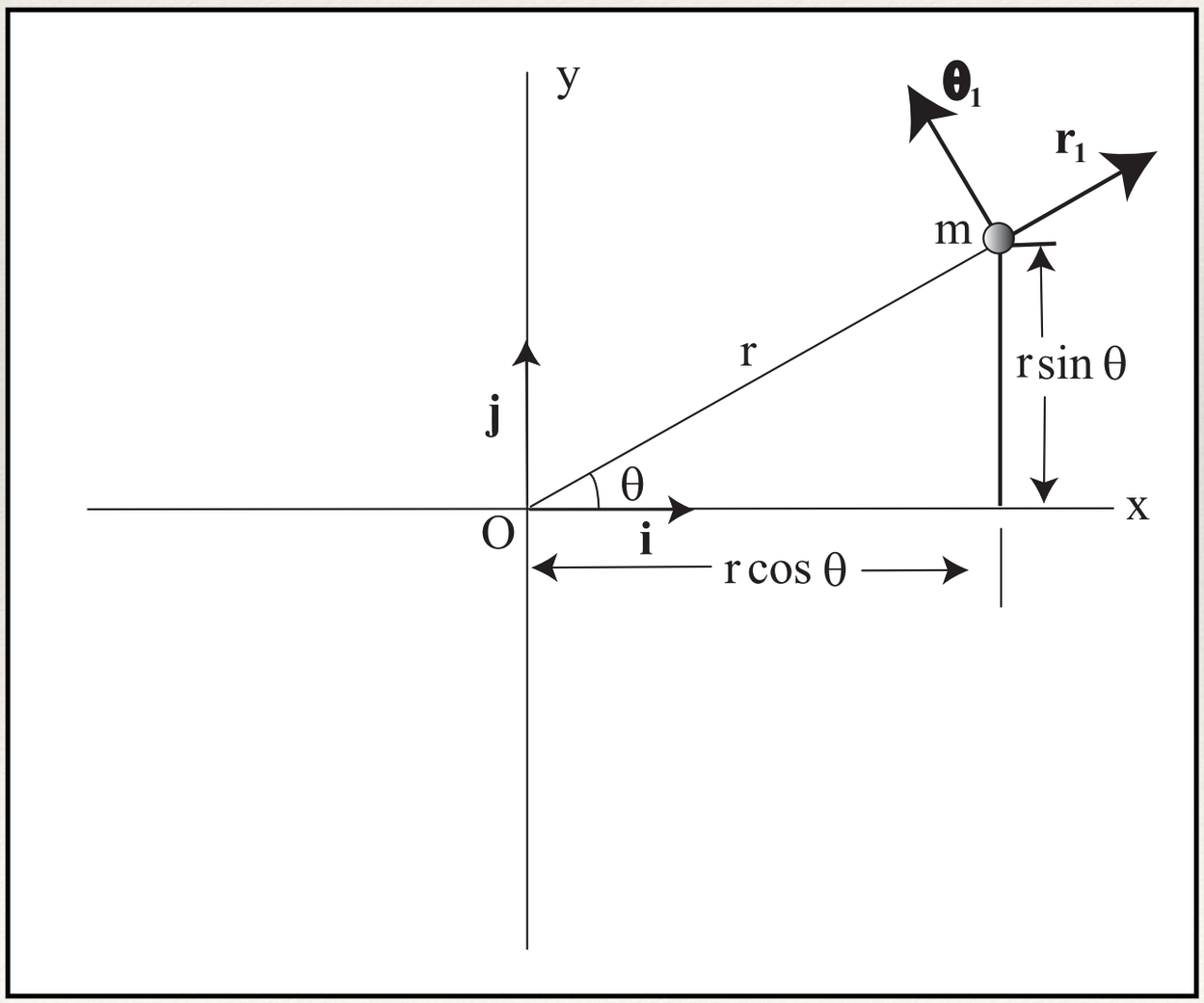
- Central Force is **conservative** !!
- Angular Momentum is conserved !!
- Motion due to central force is in a plane containing the points P and O.

Some Examples

- Gravitational
- Coulomb Attraction/Repulsion
- Simple Harmonic Oscillation.

Central Force Motion in Polar Co-ordinates.

Consider a test mass **"m"** moving in the influence of central force.
Here we express the motional quantities in Polar co-ordinates.



$$\hat{r} = \vec{r}/|r| = \cos\theta\hat{i} + \sin\theta\hat{j}$$

$$\hat{\theta} = -\sin\theta\hat{i} + \cos\theta\hat{j}$$

$$\dot{\hat{r}} = \dot{\theta}\hat{\theta}; \dot{\hat{\theta}} = -\dot{\theta}\hat{r}$$

$$\vec{v} = \dot{\vec{r}} = \dot{r}\hat{r} + r\dot{\theta}\hat{\theta}$$

$$\vec{a} = \ddot{\vec{r}} = (\ddot{r} - r\dot{\theta}^2)\hat{r} + (r\ddot{\theta} + 2\dot{r}\dot{\theta})\hat{\theta}$$

Constant of Motion.

Using Equation of Motion.

$$\vec{F} = m\vec{a}$$

$$m(\ddot{r} - r\dot{\theta}^2) = F(r)$$

$$m(r\ddot{\theta} + 2\dot{r}\dot{\theta}) = 0 \rightarrow r^2\dot{\theta} = \mathcal{C}$$

From Definition of Torque.

$$\vec{N} = \vec{r} \times \vec{F}$$

$$\vec{N} = \frac{d}{dt}\vec{L}$$

$$\vec{F} = F(r)\hat{r} \rightarrow \vec{L} = \vec{C}$$

- Vector Angular momentum is constant ! —> Planar motion.
- *Exercise : Show that the particle moves such that the position vector sweeps out equal areas in equal times.*

Alternative Forms of Eq. of Motion.

Non-linear Differential Equation

$$\ddot{r} - \frac{\mathcal{C}}{r^3} = \frac{F(r)}{m}$$

Second Order Homgenous D.E.

$$\frac{d^2u}{d\theta^2} + u = -\frac{F(1/u)}{m\mathcal{C}^2u^2}; u = 1/r$$

Conservative Force.

- Total energy is conserved —> E = k.e + p.e. = constant.
- Work done by the force in moving the particle between two points is independent of the path taken.

$$\vec{F} \cdot d\vec{r} = -dV \rightarrow V = -\int F(r)dr; \vec{F} = -\nabla V$$

Total Energy

$$E = \frac{1}{2}m(\dot{r}^2 + r^2\dot{\theta}^2) - \int F(r)dr$$