

Lecture 10 Notes: The ISM and Galaxy Morphology

Notes based on lectures by Yogesh Wadadekar

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1 The Interstellar Medium (ISM)

1.1 Basic Composition and Properties

The ISM consists of:

- Gas (70-80% hydrogen, 20-25% helium, 1% metals)
- Dust grains (ice and carbon-rich materials)
- Cosmic rays
- Magnetic fields

1.2 Forms of the ISM

The ISM exists in several distinct phases:

- Molecular Clouds: Cold (10-20 K), dense regions where stars form
- HII Regions: Hot (10,000 K), ionized regions around young massive stars
- Diffuse Clouds: Warm atomic gas
- Coronal Gas: Very hot (10⁶ K), diffuse plasma
- Dust: Small solid particles that absorb and scatter starlight

1.3 Observation Techniques

The ISM can be studied through:

- Emission line spectroscopy
- Absorption line studies
- Infrared and submillimeter observations
- Radio astronomy
- Polarization measurements

2 Galaxy Morphology and Classification

2.1 Historical Context

Key developments:

- 1755: Kant's "Island Universes" concept
- 1912: Slipher's discovery of nebular rotation
- 1920: Shapley-Curtis debate
- 1925: Hubble's discovery of Cepheids in Andromeda

2.2 Galaxy Components

Mass distribution in typical galaxies:

- Dark Matter: ~ 1000 parts
- Stars: ~ 100 parts
- Gas: ~ 10 parts
- Dust: ~ 1 part

2.3 Hubble Classification

The Hubble sequence classifies galaxies into:

- Ellipticals (E0-E7)
- Lenticulars (S0)
- Spirals (Sa-Sc)
- Barred Spirals (SBa-SBc)
- Irregulars

2.4 Mass-to-Light Ratios

Important relationships:

- For main sequence stars: $L \propto M^{3.5}$
- M/L ratio: $(M/L) \propto M^{-2.5} \propto L^{-0.71}$
- Typical galaxy: $M/L_V \sim 6$, $M/L_B \sim 10$
- Range: $2 < M/L_B < 20$

3 Further Reading

3.1 ISM Studies

- Draine, B.T. "Physics of the Interstellar and Intergalactic Medium" (Princeton)
- Tielens, A.G.G.M. "The Physics and Chemistry of the Interstellar Medium" (Cambridge)
- The Cloudy code documentation and papers by Gary Ferland

3.2 Galaxy Morphology

- Hubble, E. "The Realm of the Nebulae" (1936)
- Sandage, A. "The Hubble Atlas of Galaxies" (1961)
- de Vaucouleurs, G. "The Classification of Galaxies" (1959)

4 Advanced Topics for Further Study

- Role of magnetic fields in the ISM
- Star formation in molecular clouds
- Galaxy evolution and morphological transformations
- Environmental effects on galaxy morphology
- Dark matter distribution in different galaxy types
- Modern galaxy classification schemes using machine learning