3. Magnetic Fields in Molecular Clouds – Science & Technology

Scientists have "seen" the skeleton of the magnetic field surrounding small molecular clouds L1604 and L121 for the first time.Study conducted by Aryabhatta Research Institute of Observational Sciences (ARIES), Department of Science and Technology (DST) in collaboration with Assam University. Methodology- R-band polarimetry using ARIES Imaging Polarimeter (AIMPOL) on the 104-cm ARIES telescope, Nainital.

1.Introduction

1. Molecular clouds are critical components of the interstellar medium, serving as the primary sites of star formation in galaxies.
2. Recent studies on clouds such as L1604 and L121 have provided new insights into the role of magnetic fields in regulating star formation.
3. These findings deepen our understanding of how gravity, turbulence, and magnetism interact to shape stellar and galactic evolution.

2.About Molecular Clouds

Concept and Nature

1. Molecular clouds are cold, dense regions of gas and dust where molecules, particularly molecular hydrogen, exist.
2. They are often referred to as stellar nurseries because they provide the conditions necessary for star formation.
3. Their low temperatures and high densities allow atoms to combine into molecules and remain stable.

Physical Characteristics

1. Molecular clouds typically have temperatures ranging from 10 to 30 Kelvin, making them among the coldest regions in space.
2. Their densities are significantly higher than the surrounding interstellar medium, ranging from 100 to 1,000,000 particles per cubic centimetre.
3. They are primarily composed of molecular hydrogen, along with helium, carbon monoxide, and trace organic molecules.
4. Dust grains constitute about 1 percent of their mass and play a crucial role in shielding molecules from radiation.

3.Types of Molecular Clouds

Bok Globules

1. These are small, isolated, and dense clouds.
2. They are typically associated with the formation of single stars.

Dark Clouds

1. These appear as dark patches against the background of stars due to their ability to block visible light.
2. They are dense enough to obscure starlight completely.

Giant Molecular Clouds

1. These are massive structures containing thousands to millions of solar masses.
2. They are sites of large-scale star formation and often give rise to star clusters.

4.Key Findings from Study of L1604 and L121

Magnetic Field Dominance at Large Scales

1. Both L1604 and L121 are sub-critical clouds, meaning magnetic energy dominates over gravitational and turbulent forces at the envelope level.
2. Magnetic fields act as a stabilising force, preventing rapid collapse of gas.

Formation of Dense Cores

1. Despite magnetic support at larger scales, gravity can dominate within dense cores.
2. These cores become sites of star formation where gas collapses under its own gravity.

Differences Between L1604 and L121

1. L1604 is more massive and denser, with a less ordered magnetic field structure.
2. In this cloud, gravity plays a stronger role in dense regions, increasing star formation potential.
3. L121 is less dense and exhibits a stronger, more ordered magnetic field.
4. The stronger magnetic field resists gravitational collapse, resulting in lower star formation activity.

Magnetic Fields as a Regulating Force

1. Magnetic fields act as an invisible control mechanism, slowing down star formation.
2. They prevent rapid depletion of gas, ensuring sustained star formation over time.

5.Significance of the Study

Regulation of Star Formation

1. The study demonstrates that magnetic fields play a crucial role in controlling the rate at which stars are formed.
2. This prevents sudden bursts of star formation that could exhaust gas reserves quickly.

Implications for Galaxy Evolution

1. By regulating star formation, magnetic fields help maintain a stable stellar population in galaxies.
2. This contributes to long-term galactic stability and evolution.

Observational Breakthrough

1. The study provides one of the first direct mappings of magnetic field structures in small molecular clouds.
2. It enhances observational capabilities in astrophysics.

Advancement of Theoretical Understanding

1. The findings improve understanding of the interplay between gravity, turbulence, and magnetic fields.
2. This contributes to more accurate models of star formation and cosmic evolution.

6.Importance of Molecular Clouds

Birthplace of Stars

1. Molecular clouds are the primary sites where stars are formed through gravitational collapse of dense regions.
2. They ensure the continuous generation of new stars in galaxies.

Formation of Planetary Systems

1. The collapse of dense cores leads to the formation of protoplanetary disks.
2. These disks eventually evolve into planetary systems.

Regulation of Star Formation Rate

1. The balance between gravity, thermal pressure, turbulence, and magnetic fields controls star formation.
2. This prevents rapid exhaustion of interstellar gas.

Role in Galactic Evolution

1. Molecular clouds act as reservoirs of gas and dust, influencing the structure and lifecycle of galaxies.
2. Star formation within these clouds determines the composition and evolution of galaxies.

Chemical Enrichment of the Universe

1. Molecular clouds contain complex molecules, including organic compounds.
2. They contribute to the chemical evolution of the universe and may play a role in the formation of prebiotic molecules.

Conclusion

1. The study of molecular clouds such as L1604 and L121 highlights the critical role of magnetic fields in regulating star formation.
2. It provides valuable insights into the fundamental processes shaping galaxies and the universe.
3. Understanding these mechanisms is essential for advancing astrophysical research and explaining the origins of stars and planetary systems.

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