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Chapter 1 : the physics of the interstellar medium second edition | Download eBook PDF/EPUB

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These phases are the temperatures where heating and cooling can reach a stable equilibrium. Their paper formed the basis for further study over the past three decades. However, the relative proportions of the phases and their subdivisions are still not well known. Temperature larger than K breaks molecules, lower than 50 K leaves atoms in their ground state. It is assumed that influence of other atoms He Suppose that a monochromatic light is pulsed, then scattered by molecules having a quadrupole Raman resonance frequency. While light generated by incoherent Raman at a shifted frequency has a phase independent on phase of exciting light, thus generates a new spectral line, coherence between incident and scattered light allows their interference into a single frequency, thus shifts incident frequency. Assume that a star radiates a continuous light spectrum up to X rays. Lyman frequencies are absorbed in this light and pump atoms mainly to first excited state. However, where a previously absorbed line first Lyman beta, But the stop is not perfect if there is energy at frequency shifted to Lyman beta frequency, which produces a slow redshift. I is the modulus of Poynting vector of field, absorption occurs for an opposed vector, which corresponds to a change of sign of B. Factor I in this formula shows that intense rays are more amplified than weak ones competition of modes. Emission of a flare requires a sufficient radiance I provided by random zero point field. After emission of a flare, weak B increases by pumping while I remains close to zero: De-excitation by a coherent emission involves stochastic parameters of zero point field, as observed close to quasars and in polar auroras. Three-dimensional structure in Pillars of Creation. Stars are born deep inside large complexes of molecular clouds , typically a few parsecs in size. During their lives and deaths, stars interact physically with the ISM. Stellar winds from young clusters of stars often with giant or supergiant HII regions surrounding them and shock waves created by supernovae inject enormous amounts of energy into their surroundings, which leads to hypersonic turbulence. The resultant structures â€" of varying sizes â€" can be observed, such as stellar wind bubbles and superbubbles of hot gas, seen by X-ray satellite telescopes or turbulent flows observed in radio telescope maps. The Sun is currently traveling through the Local Interstellar Cloud , a denser region in the low-density Local Bubble. The interstellar medium begins where the interplanetary medium of the Solar System ends. The solar wind slows to subsonic velocities at the termination shock , 90â€" astronomical units from the Sun. In the region beyond the termination shock, called the heliosheath , interstellar matter interacts with the solar wind. Voyager 1 , the farthest human-made object from the Earth after [5] , crossed the termination shock December 16, and later entered interstellar space when it crossed the heliopause on August 25, , providing the first direct probe of conditions in the ISM Stone et al. Interstellar extinction[edit] The ISM is also responsible for extinction and reddening , the decreasing light intensity and shift in the dominant observable wavelengths of light from a star. These effects are caused by scattering and absorption of photons and allow the ISM to be observed with the naked eye in a dark sky. The apparent rifts that can be seen in the band of the Milky Way â€" a uniform disk of stars â€" are caused by absorption of background starlight by molecular clouds within a few thousand light years from Earth. Far ultraviolet light is absorbed effectively by the neutral components of the ISM. For example, a typical absorption wavelength of atomic hydrogen lies at about Therefore, it is nearly impossible to see light emitted at that wavelength from a star farther than a few hundred light years from Earth, because most of it is absorbed during the trip to Earth by intervening neutral hydrogen. Heating and cooling[edit] The ISM is usually far from thermodynamic equilibrium. Depending on the temperature, density, and ionization state of a portion of the ISM, different heating and cooling mechanisms determine the temperature of the gas. Heating by low-energy cosmic rays The first mechanism proposed for heating the ISM was heating by low-energy cosmic rays. Cosmic rays are an efficient heating source able to penetrate in the depths of molecular clouds. Cosmic rays transfer energy to gas through both ionization and excitation and to free electrons through Coulomb interactions. Low-energy cosmic rays a few MeV are more important because they are far more numerous than high-energy cosmic rays. Photoelectric heating by grains The ultraviolet radiation emitted by hot stars can remove electrons from dust grains. The photon is absorbed by the dust grain, and some of its energy is used to overcome the potential energy barrier and remove the electron from the grain. This potential barrier is due to the binding energy of the electron the work function and the charge of the grain. This indicates that the smallest dust grains dominate this method of heating [7]. X-ray heating X-rays remove electrons from atoms and ions , and those photoelectrons can provoke secondary ionizations. As the intensity is often low, this heating is only efficient in warm, less dense atomic medium as the column density is small. For example, in molecular clouds only hard x-rays can penetrate and x-ray heating can be ignored. This is assuming the region is not near an x-ray source such as a supernova remnant. Chemical heating Molecular hydrogen H2 can be formed on the surface of dust grains when two H atoms which can travel over the grain meet. This process yields 4. This kinetic energy, as well as the energy transferred from de-excitation of the hydrogen molecule through collisions, heats the gas. Grain-gas heating Collisions at high densities between gas atoms and molecules with dust grains can transfer thermal energy. It is also not important in diffuse ionized medium due to the low density. In the neutral diffuse medium grains are always colder, but do not effectively cool the gas due to the low densities. Grain heating by thermal exchange is very important in supernova remnants where densities and temperatures are very high. Gas heating via grain-gas collisions is dominant deep in giant molecular clouds especially at high densities. Far infrared radiation penetrates deeply due to the low optical depth. Dust grains are heated via this radiation and can transfer thermal energy during collisions with the gas. A measure of efficiency in the heating is given by the accommodation coefficient:

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Here is an introduction to the theory of atomic and molecular collision processes which occur in the interstellar medium. The text deals primarily with processes that occur in interstellar molecular clouds, where the electron density is low and collisions with the abundant neutral species H, H2 and He predominate.

Chapter 7 : Physics and Chemistry of the Interstellar Medium

Molecular collisions in the interstellar medium, by David Flower. Cambridge: University Press, vii, p. Cambridge astrophysics series, vol. 42 1. Interstellar molecules; 2. Interstellar shocks and chemistry; 3. The primordial gas; 4. The rotational excitation of molecules; 5. The vibrational.