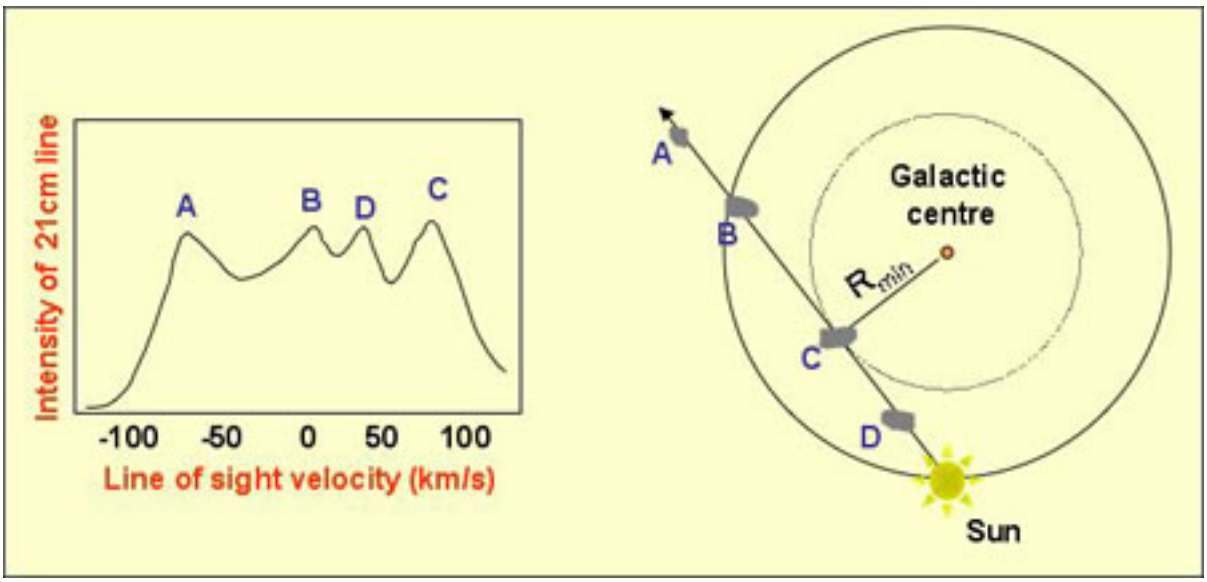
Answer on Question #69704, Physics / Astronomy | Astrophysics

Describe the composition of the interstellar medium. Explain how it has been possible to map the HI clouds.

Solution:

The interstellar medium (ISM) is the material which fills the space between the stars. These regions have very low densities and consist mainly of gas (99%) and dust. The chemical composition of the interstellar medium is very similar to the chemical composition which we see in stars. The mass of interstellar medium about 75% is in the form of hydrogen (either molecular or atomic), with the remaining 25% as helium. The regions with denser density can collapse due to the mutual gravitational attraction of the gas into stars. The interstellar gas consists partly of neutral atoms and molecules, as well as charged particles, such as ions and electrons.

The ISM is not uniform: some regions are denser and are called interstellar clouds. Interstellar gas clouds consisting mostly of neutral hydrogen atoms (commonly called HI, or H-one atoms by astronomers) are usually referred to as HI clouds. They are very abundant, but mainly confined to the spiral arms in the disks of galaxies in a layer less than 300 light years thick. Because they are cold, they do not emit radiation in the visible part of the spectrum. Rather, they are detected using the spin-flip transition at 21 cm in the radio, and have been particularly important in mapping out the structure of our own Galaxy. Radio waves are largely unaffected by dust, allowing us to detect HI clouds throughout our Galaxy. Each HI cloud along a particular line of sight will be moving at a slightly different speed relative to us, meaning that the 21 cm radiation emitted by the cloud will be Doppler shifted by a different amount when it arrives at our telescopes.



In this example, the existence of a HI cloud is shown as a peak in the intensity of the 21cm emission. A cloud that is orbiting at the same radius as the Sun (B) will have a line of sight velocity of zero since it is moving at the same speed as the Sun. Clouds with orbits closer to the Galactic centre will be moving faster than the Sun and will have positive line of sight velocities (B, D), while clouds located further from the Galactic centre (A) will have negative line of sight velocities since they are moving slower than the Sun. Put another way, the cloud with the highest line of sight velocity (C) is closest to the centre of the galaxy and the cloud with the lowest line of sight velocity (A) is the most distant from the centre.

By observing HI clouds along many different lines of sight we were able to build up a map of the HI clouds in our Galaxy to discover that we live in a spiral galaxy with four major spiral arms.