

PowerPoint Notes on the 21-cm Line

Slide 1: What makes the 21-cm line (1420 MHz) found in the radio spectrum is the fact that hydrogen is the most abundant element in the universe. Hydrogen was created in the Big Bang and is everywhere. In this slide we see a spiral galaxy with very dusty center.

Slide 2: Atoms emit photons which are both wavelike and particle-like. The Bohr model first gave an explanation of this. The energy and hence color is due to the energy level differences.

Slide 3: A spectrometer is an instrument that measures the emission lines and their intensity. It consists of a light source, a separator, and a detector. In stars we will see a dark line spectrum because the light from a star is absorbed in the star's atmosphere and then remitted in three dimensions but much less strongly in a single direction. Hence, it looks dark.

Slide 4: The spectrum of an element is unique. Lines always appear at the same positions. Consequently, it is a signature for an element. This works because each element has its own electronic and nuclear structure.

Slide 5: If hydrogen is not excited electronically, can it still emit a photon indicating an energy level change?

Slide 6: Yes, due to the fact that the parallel spin coupling of the proton and electron is slightly higher in energy than the antiparallel spins. When the spins go from parallel to antiparallel, a photon with wavelength of 21 cm is emitted.

Slide 7: Another visual animation of this spin change.

Slide 8: This slide shows the 21-cm line at the galactic center of the Milky Way.

Slide 9: Spectral lines can shift from their rest position if the source is moving. This is called the Doppler effect and is commonly experienced in sound. Think about an emergency vehicle and the sound it makes as it approaches you and then recedes from you. That is the Doppler Shift. Because it moves to lower frequencies, it is called the red shift by astronomers.

Slide 10: An animations that illustrates the line shift due to the moving source.

Slide 11: Another slide on the line shift. It relates to the change in wavelength as the source as it moves toward and away from the observer.

Slide 12: Another slide on the line shift. It relates to the change in wavelength to the change in velocity of the source as it moves toward and away from the observer

Slide 13: The 21-cm line is excellent for finding galactic rotation. There's so much hydrogen and radio waves are not absorbed by interstellar dust. It is the best way to map the Milky Way.

Slide 14: This shows a flat on image of the Milky Way, a Small Radio Telescope, the instrument used to do the measurements and how the shift is related to the spin of the galaxy. Note: You wouldn't see any Doppler shift if you look at a galaxy as shown in the slide. Why?