# PowerPoint Notes on MASERs

**Slide 1**: What is a MASER? MASER is an anachronism for **M**icrowave **A**mplified **S**timulated **E**mission of **R**adiation. MASERs are formed in cold, dark nebulae.

**Slide 2**: Most students have heard of LASERs—Star Wars light Sabers. But they have not heard of MASERs. MASERs are actually the same as LASERs except they emit microwave radiation instead of the higher frequencies in the electromagnetic spectrum. MASERs were actually created in the lab in 1954, and the first astronomical MASER was found about ten years later in 1965.

**Slide 3**: Spontaneous emission occurs when a photon with frequency that matches the electron's energy level jump hits that electron. When it does, the electron falls to the lower energy level emitting a photon with the same energy as the first. We now see two photons.

**Slide 4**: We see the letters A, S and E. The missing M stands for the type of electromagnetic radiation. The letters are starting to spell out MASER. The principle for both MASERs and LASERs is the same. If an electron is excited, it will emit a photon when stimulated by a photon of exactly the **same** frequency. When this happens, we get a cascading of electrons: 1 begets 2, 2 begets 4, etc. This creates a very coherent powerful beam of radiation.

**Slide 5**: Coherent radiation results, the light is in the same phase and the power is amplified as the photons move in the same direction.

**Slide 6**: This summarized the advantages of MASERs. A MASER is intense, has a narrow concentrated beam that is directed, and at a single frequency. Quite a powerful thing!

**Slide 7**: Where do we find astronomical MASERs? They are formed in dark nebulae in cold regions of space where stars are forming. However, light is needed to pump the electrons to an excited level. One source of this light can be a newly formed star, often large and bright, and often hidden or an old star giving large amounts of energy. Another source can be the proximity to a huge and energetic galactic black hole. Methanol emission form the source G23.657-0.127 shows a remarkable ring structure around the supposed position of a young star. Motion studies may reveal if this ring is expanding and/or rotating.

**Slide 8**: MASERs are usually associated with water or small organic molecules like methanol or formaldehyde. However, they can be inorganic too. An example is the SiO MASER shown here that is pulsating.

**Slide 9**: The Trifid nebula, shown in the picture, has MASERs. MASERs give us an insight into interstellar matter. Another important use is that MASERs are the most accurate timepiece in the Universe, accurate to 1 second in a million years. We encountered this in our presentation of "Plate Tectonics, Geodesy, and VLBI" in which used MASERs to time the incoming quasar signals.

**Slide 10**: Because of their powerful signals, they can be detected over long distances, billions of light years away. About 50 years ago it was thought that simple organic molecules could only be made on a planet like Earth. However, through research on MASERs and nebulae where they form, it has been discovered that small organic molecules can also be made in deep dark nebulae.