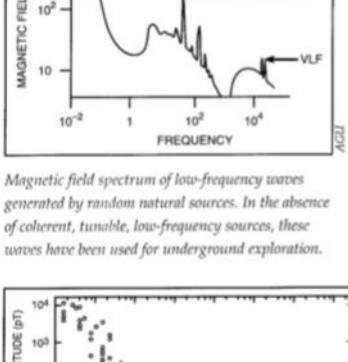
APPLICATIONS

Low Frequencies

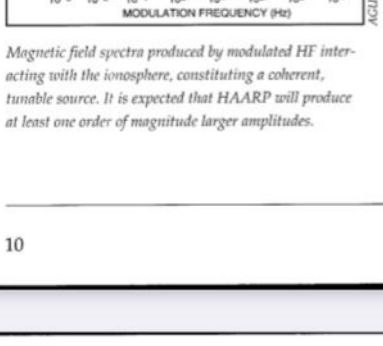
Most communication systems and remote sensors use the short wavelength portion of the electromagnetic spectrum, operating from several megahertz to the visible and ultraviolet. These frequencies have inherent advantages in terms of bandwidth, resolution, and ease in the development and deployment of sources and detectors. However, their poor penetrating capability constitutes a major impediment when used for probing or communicating deep into the ground or the sea.

Low frequencies penetrate much deeper into the ground and the sea and have been used for submarine communications and geophysical exploration. However, problems in developing efficient broadband low-frequency sources make the use of low frequencies for subterranean applications difficult. As a result, low-frequency electromagnetic applications have often relied on natural sources, such as lightning and geomagnetic pulsations. But, while natural sources have logistic and interpretative advantages over small artificial sources, they suffer from their inherent unpredictability and the noiselike characteristics of their signal. Furthermore, natural signals are extremely weak in the 1 to 2 kHz and 0.1 to 10 Hz frequency bands. These bands are important in mineral and petroleum exploration.

The HAARP heater, operating in the low-frequency conversion mode, generates controlled, monochromatic, coherent waves between 0.001 Hz and 40 kHz. This source has all the advantages of the natural sources and none of their disadvantages. Thus HAARP fills a long-standing vacuum in controlled electromagnetic sources, with the potential to revolutionize low-frequency remote sensing and communications.



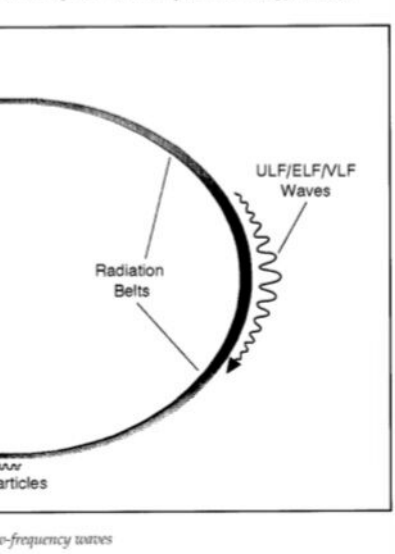
Magnetic field spectrum of low-frequency waves generated by random natural sources. In the absence of coherent, tunable, low-frequency sources, these waves have been used for underground exploration.



Magnetic field spectra produced by modulated HF interacting with the ionosphere, constituting a coherent, tunable source. It is expected that HAARP will produce at least one order of magnitude larger amplitudes.

Low frequencies propagate as guided waves in the waveguide formed between the conducting ground and the ionosphere, suffering weak attenuation. As a result, a significant fraction of the Earth can be covered from the HAARP site.

Low-frequency waves injected in the Earth's radiation belts can induce precipitation of the energetic particles trapped in this region of geospace. Harnessing this process could allow control of the flux of energetic particles in particular regions of the radiation belts and could impact the operation and lifetimes of satellites operating in this geospace region.



Expected coverage from HAARP at 100 Hz. The coverage increases faster than linearly with decreasing frequency.

Precipitation of radiation belts particles induced by injection of low-frequency waves