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Applications of short duration HF pulses to study initial plasma processes after HF turn-on

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Experimental results from the HAARP ionospheric modification facility at Gakona, Alaska have been used to study the plasma effects immediately after high-power turn-on. Results from a 446MHz diagnostic radar with 600m range resolution and 10ms time resolution were used where the HF power was cycled with 1% 5% 20% 50% and 100% of full power (1 GW ERP) and frequency of 4.5MHz. Both HAARP and radar antennas were directed to magnetic zenith. During the initial 100ms very strong radar scatter is observed for all power levels. Experimental evidence suggests these strong brief signals probably occur from non-propagating irregularities within the 'evanescent' region just above the HF cut-off height; ponderomotive and thermal pressure forces in the vertical direction generate non-oscillatory density fluctuations that scatter UHF radar signals. The spectral response of these signals are near zero Doppler, relatively distant in frequency from the +/- 5Khz typically observed due to ion-line signals that occur at a later time and only at high HF powers (about 20% or greater for this example). Subsequent radar scattering is observed from ion-line signals about 8-10km lower altitude. The HF frequency is not near an electron gyro-harmonic. Artificial ionization due to temperature dependence of NO^+ and O_2^+ ion recombination rates result in slow density increases and corresponding decreasing altitudes of ion-line signals. This non-resonant process shows the rate of altitude decrease of radar signals that results from the ionization production depends on HF power.

Two new applications are suggested that utilize short (~20 – 50ms) duration high-power HF pulses. First, the strong initial response signals that occur very close to the HF cut-off height may be used to obtain an electron density profile (with limitations) by using short HF on-off cycles (eg 20ms on – 980ms off). Favorable comparison with an ionogram is shown. The short duration HF pulse enables the detection of the strong initial impulse, but precludes the generation of artificial ionization and onset of ion-line signals. Second, short duration HF pulses may be used to determine chemical recombination times for the ionospheric plasma. This is achieved by first creating artificial ionization with an extended period of HF power on, then immediately followed by 20ms on-980ms off cycles, that does not significantly modify the background ionosphere. The temporal record of recombination is clearly evident; at 190km the recombination time is about 20 seconds.

Another example for HF frequency of 2.85 MHz (close to 2nd electron gyro-harmonic level) is shown where the ionization was created about 150km altitude. Short-pulse HF on-off cycles then show evidence for a distinct ionization layer that decays in about 10 secs. For this case the HF frequency corresponds to an upper-hybrid resonance where the circular-polarized HF wave, via upper-hybrid waves from a resonant parametric process, results in rapid artificial ionization production and the HF interaction height drops to about 150km considerably more rapid than the non-resonant case mentioned above.