Low Altitude Artificial Auroras

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Artificial airglow occurs when, due to the interaction of a powerful electromagnetic wave with the ionospheric plasma, electrons acquire enough energy for collisional excitation of a neutral species. When the latter relax they emit photons, very much like it happens in natural aurora caused by precipitating energetic electrons. That is why we call these radiowave-induced optical emissions radiowave-induced aurora or artificial aurora. The most commonly observed and well studied is the red-line aurora from the atomic oxygen $O(^1D)$ state (the excitation energy is 1.96 eV and the life time in the excited state under natural conditions is about 90 s), that on rare occasions was accompanied by much weaker green-line (557.7-nm) emission from $O(^1S)$ (the excitation energy 4.17 eV; life time in the excited state is 0.17 s). I will focus on low-altitude (E-region) radiowave-induced auroras that are relatively recent discovery and are not that well understood nor studied as the 630.0-nm emission from $O(^1D)$. The latter comes from 200-300 km altitude and has not been observed in the E region since at lower altitudes $O(^1D)$ quenched by collisions before it emits 630.0-nm photon.

E-region artificial auroras are closely associated with E-region sporadic ionization (Es) that enhances the energy of the launched radiowaves by either reflection or focusing. There are not many observations of these emissions. The main reason for that is absence of Es during optical/heating observations. Under exceptional circumstances (e.g. the 557.7-nm radiowave-induced aurora reported by Pedersen & Gerken in Nature, v.433, p.498, 2005) the overall power increase could be 400-450 times compared to the effective radiated power of launched radiowaves!

I'll discuss the two E-region emissions that have been observed: the green-line emission from atomic oxygen at 557.7 nm (the excitation energy is 4.17 eV) and red hydroxyl emission (the excitation energy is 3.45 eV) within a 2-nm window near 630.0 nm, and will outline mechanisms and necessary ionosphere conditions for their generation.

The 557.7-nm artificial aurora may be used for studying the structure and dynamics of sporadic ionization clouds, tracking the source region of energetic electrons, and finding neutral winds. Besides the information on structure and dynamics of sporadic ionization clouds the radiowave-induced OH aurora may give information on local temperature and water content in the atmosphere near 87 km.