PRINCIPLE OF A HIGH-POWER TERAHERTZ PLASMA RADIATOR

Balram Prasad[1] and Kenneth R. Grimm[2]
[1]*Physical Scientist, retired , Defense Threat Reduction Agency, Ft Belvoir, VA (Currently consultant ITT Advance Science & Engineering)*
[2]*Electromagnetic Research Engineer, BAE Systems Inc., Technology Solutions and Services, Ft Belvoir, VA*

A comprehensive theory of MASER for gaseous plasma has been recently completed by the authors to be published in the J. Plasma Physics, UK. The proof-of-principle of the socalled "plasma maser" was experimentally demonstrated in 1984 at the nuclear engineering school, University of Wisconsin, ref. [1]. But an appropriate theory, explaining the quantitative and qualitative features of the observed plasma maser phenomena in the laboratory has been advanced now. The theory employs quantum mechanical three-wave scattering processes of longitudinal and /or transverse waves excited in a steady plasma volume that resulted from a quasiquantum formalistic model (QFM) published in J. Plasma Physics, by I. H. Cairns, in 1987, for explaining solar radio burst type- III phenomena. The plasma maser//radiator system consists of a stabilized cylindrical plasma volume/tube pumped by two finite radius counter streaming electron beams kept collimated by a very week dc magnetic field as in ref.[1]. The two beams-plasma interactions result in the so–called bump-on-tail instabilities at both ends of the plasma tube but they stabilize when the average energy of the two electron beams are adjusted to become equal. Then the beams plasma interactions volume in the middle region reaches a steady state and the plasma begins to radiate like a maser at twice the basic plasma frequency, ,i.e., ($2\omega_p$) and also at the third and higher harmonics of ω_p with monotonically decreased power levels discussed in refs. [2]. Analytical formula for the second harmonic radiation power P ($2\omega_p$) has been derived in our paper.. Also derived is the third and all higher harmonics radiation power that depend explicitly on the second harmonic radiation which is expressed by $P_{(n+1)}\{(n+1)\omega_p\}$, for $n > 2$. These two types of radiation power depend on the plasma and the pump electron beams parameters,, which have been optimized to predict 30 to 50 kilowatts of terahertz wave in the 0.1 to 3 THz spectral radiation . The prediction could be tested by operating the triple plasma machine used in ref. [1] and then used as a high power, hyper-band (very-wide band THz radiation source that has many applications for the national defense.

[1] T. Intrator, N. Hershkowitz, and C. Chan, "Experimental observations of nonlinearly enhanced $2\omega_{UH}$ electromagnetic radiation excited by steady-state colliding electron beams" , Phys. Fluids 27 (2), Feb. 1984.
[2] B. Prasad, "Multiple Harmonic Emission from Electron Beams Excited Gaseous Plasmas ", Abstract published in the proceedings of AMEREM Symposium 2002, Naval Post Graduate School , Annapolis, MD