Active actinometry on a cold hydrogen afterglow

Tuesday, 8 June 1993
9:45 am – Room 207
ORAL SESSION 3B
Plasma Diagnostics
Chair: N. Hershkowitz

3B1

Diagnostics of Magnetic Antenna Fields for Low Frequency Whistlers in r-*t* and ω-*k* Space*

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In a large uniform laboratory plasma ($n_e \sim 3 \times 10^{11}\mathrm{cm}^{-3}$, $kT_e \sim 2$ eV, $B_0 \sim 15$G, Ar 2×10^{-4} Torr, 1m diam. × 2.5m length) the magnetic field $\boldsymbol{B}_{(r,t)}$ of a shielded magnetic loop antenna (5 cm diam.) has been measured in both near and far zones.[1] The antenna is driven with a single short current pulse ($t_p \sim 0.2$ μs) which excites a whistler wave packet ($\omega << \omega_{ce}$). With a movable magnetic probe and repeated pulses the three-dimensional vector field B_x, B_y, B_z vs. x,y,z is mapped at 10,000 spatial positions with high time resolution (Δt = 10ns). In the space-time domain the evolution of a dispersive wave packet from the antenna near-zone ($r < \lambda$) fields is observed. The wave packet consists of nested cones propagating with wave normals highly oblique to $\boldsymbol{B}_0$ but energy flow at a small angle to $\boldsymbol{B}_0$. In order to analyze the wave packet in terms of eigenmodes, the field $\boldsymbol{B}_{(r,t)}$ has been Fourier transformed in time and three-dimensional space, $\boldsymbol{B}_{(\omega,k)}$. At a selected frequency, ω, the finite-size antenna launches a spectrum of $\boldsymbol{k}$-vectors which, for an antenna dipole moment along $\boldsymbol{B}_0$, is highly axisymmetric ($k_\perp(\phi) = const.$). In the $k_\perp$ - $k_\parallel$ plane the wave energy is spread out along the refractive index curve of whistlers with the largest wave energy oblique to $\boldsymbol{B}_0$. At different frequencies the energy distribution in $\boldsymbol{k}$-space follows the theoretical refractive index surfaces. By selecting a single ω and $\boldsymbol{k}$ the properties of plane, oblique whistlers, which are difficult to excite directly, can be investigated. For example, the polarization of $\boldsymbol{B}$ along $\boldsymbol{k}$ is readily found from an inverse FFT. Hence, the digital analysis of wave packets is a useful diagnostic technique to study wave properties.

1. R.L. Stenzel, J.M. Urrutia and C.L. Rousculp, Phys. Fluids (Feb. 1993).

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A new method of actinometry is developed to characterize the cold afterglow of an expanding thermal plasma source in hydrogen. A small electrode is placed in the afterglow to generate a local low frequency (100-500 kHz) plasma. In this plasma fast electrons are created that can excite particles from the ground state to visible light emitting levels. The atomic Balmer α line and the molecular Fulcher band are used to determine the atomic and molecular abundances of the plasma. Furthermore, rotational and vibrational populations of molecular hydrogen are studied.
The power input from the low frequency discharge is kept low enough to assure that the plasma composition and the gas temperature are not significantly influenced. Active actinometry thus offers a method to sample the composition and the ground state molecular populations of the flowing afterglow plasma. The method has succesfully been applied under plasma conditions with a low electron temperature (< 0.2 eV) and a low electron density ($< 10^{17}$ m^{-3}).

3B3

Resonant Holographic Interferometry Measurements of Laser Ablated Atom Absolute-Line-Density Profiles In Vacuum, Gases, and Plasmas.†

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Two-dimensional, species-resolved, double pulsed, holographic interferometry has been used to investigate the hydrodynamics of KrF laser ablation plumes in vacuum, gases, and RF/plasmas. To produce the laser ablation plume, a KrF excimer laser (40 ns, 248 nm, ≤ 0.8 J) was focused onto a solid aluminum target at a fluence of 1.9 - 4.7 J/cm^2. The interferograms were made using a XeCl excimer laser pumped dye laser (20 ns, ≈ 5 mJ) tuned at or near (± 0.100 nm) the 394.401 nm aluminum neutral transition from ground state. Calculations have been performed to obtain aluminum-neutral absolute-line-density profiles from the resonant fringe shift data, assuming an average kinetic plume temperature of ≈0.3 eV and a dye laser bandwidth of ≈0.0031 nm. Peak aluminum neutral line-densities of up to 9×10^{14} cm^{-2} have been measured for plumes in backgrounds of 1 Torr and 35 Torr argon, 1 Torr argon RF-plasma, and in vacuum.

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