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## NONTHERMAL RADIATION PROCESSES IN INTERPLANETARY PLASMAS

Abraham C.-L. Chian

Instituto de Pesquisas Espaciais - INPE  
Brazil

RESUMEN. En la interacción de haces de electrones energéticos con plasmas interplanetarios, se excitan ondas intensas de Langmuir debido a inestabilidad del haz de plasma. Las ondas Langmuir a su vez interactúan con fluctuaciones de densidad de baja frecuencia para producir radiaciones. Si la longitud de las ondas de Langmuir exceden las condiciones del umbral, se puede efectuar la conversión de modo no lineal a ondas electromagnéticas a través de inestabilidades paramétricas. Así se puede excitar en un plasma inestabilidades paramétricas electromagnéticas impulsadas por ondas intensas de Langmuir: (1) inestabilidades de decaimiento/fusión electromagnética impulsadas por una bomba de Langmuir que viaja; (2) inestabilidades dobles electromagnéticas de decaimiento/fusión impulsadas por dos bombas de Langmuir directamente opuestas; y (3) inestabilidades de dos corrientes oscilatorias electromagnéticas impulsadas por dos bombas de Langmuir de corrientes contrarias. Se concluye que las inestabilidades paramétricas electromagnéticas inducidas por las ondas de Langmuir son las fuentes posibles de radiaciones no térmicas en plasmas interplanetarios.

ABSTRACT: Nonthermal radio emissions near the local electron plasma frequency have been detected in various regions of interplanetary plasmas: solar wind, upstream of planetary bow shock, and heliopause. Energetic electron beams accelerated by solar flares, planetary bow shocks, and the terminal shock of heliosphere provide the energy source for these radio emissions. Thus, it is expected that similar nonthermal radiation processes may be responsible for the generation of these radio emissions. As energetic electron beams interact with interplanetary plasmas, intense Langmuir waves are excited due to a beam-plasma instability. The Langmuir waves then interact with low-frequency density fluctuations to produce radiations near the local electron plasma frequency. If Langmuir waves are of sufficiently large amplitude to exceed the threshold conditions, nonlinear mode conversion into electromagnetic waves can be effected through parametric instabilities. A number of electromagnetic parametric instabilities driven by intense Langmuir waves can be excited in a plasma: (1) electromagnetic decay/fusion instabilities driven by a traveling Langmuir pump; (2) double electromagnetic decay/fusion instabilities driven by two oppositely directed Langmuir pumps; and (3) electromagnetic oscillating two-stream instabilities driven by two counterstreaming Langmuir pumps. It is concluded that the electromagnetic parametric instabilities induced by Langmuir waves are likely sources of nonthermal radiations in interplanetary plasmas.

Key words: INTERPLANETARY MEDIUM — PLASMAS

## I. INTRODUCTION

Nonthermal radiations in the vicinity of the local fundamental electron plasma frequency  $f_p$  have been detected in three distinct regions of the interplanetary medium: solar

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