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Numerical modeling of laser matter interaction in the presence of an ambient gas

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Abstract. A one dimensional numerical model to simulate the laser matter interaction in the presence of an ambient gas is presented. The model is developed by making appropriate modifications in MEDUSA, a one dimensional Lagrangian computer code, which simulates laser plasma interaction in vacuum. Various parameters of the plasma such as velocity, electron temperature, ion temperature, density, pressure, shock wave intensity of the plasma as it expands into a background gas are simulated. The results are compared with the experimental observations.

Keywords. Ablation; modeling; laser; ambient gas; MEDUSA.

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1. Introduction

The study of laser-matter interaction has been a subject of paramount importance in recent years. There have been reports on laser-matter interaction in the presence of an ambient gas [1–6], electric field [7, 8] and magnetic field [9]. The genesis of this study is to understand the interaction of a high power pulsed laser beam with a solid target in the presence of an ambient gas and to develop a comprehensive numerical model for the process. The laser ablation at moderate intensity is particularly important because of its application in thin film deposition [3] and laser drilling [10–12]. Further, the interaction between laser produced plasma and ambient gas is of interest because it provides information on collisional, collective and electromagnetic processes in astrophysical and laboratory plasmas [13] and can help in the solution of various practical problems [14].

Since late seventies there have been several attempts to develop a theoretical model for understanding laser-matter interaction in ambient atmosphere but every model has some limitations. Knight [15] developed a theoretical model which was generalized by Bellantone *et al* [10, 11] but its usage was restricted to relatively low intensity regime. Aden *et al* [12] developed a three dimensional model which matched well with their experimental data. Macfarlane *et al* [16] and Giuliani *et al* [17] had given two separate models for the same experiment which was valid above 1 Torr but failed at higher pressure. Ananin *et al* [18] had given a model for plasma expansion at low