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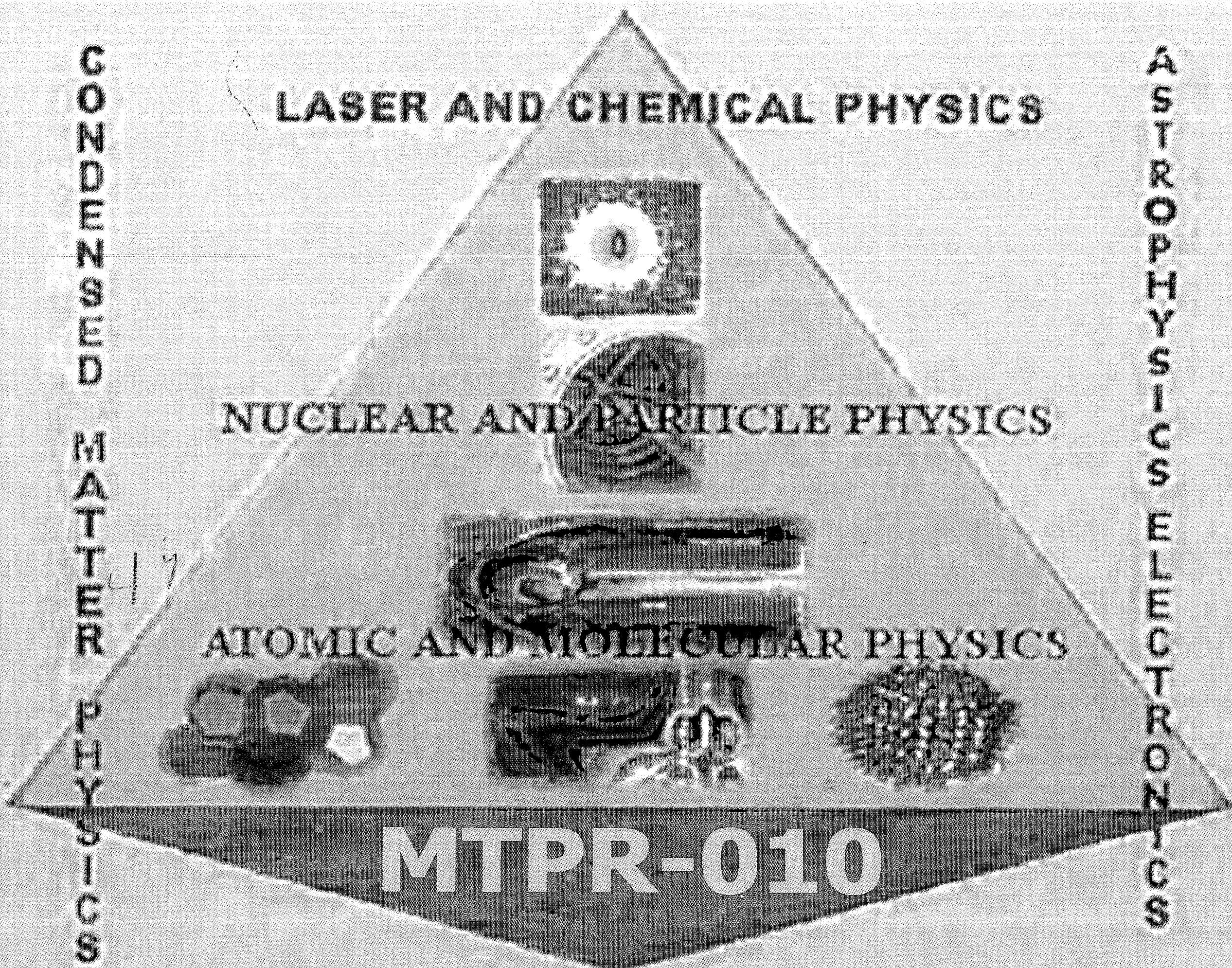

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Photo-excitation and Photoionization for Plasma Opacities under the Iron Project

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ABSTRACT: Opacity gives a measure of radiation transport in astrophysical plasmas. It is caused by the absorption and emission by the constituent elements in the plasmas through which the radiation propagates. Higher or lower opacity indicates more or less attenuation of radiation. Hence opacity depends mainly on two intrinsic atomic processes, photo-excitation in a bound-bound transition and photoionization in a bound-free transition. So monochromatic opacity for a particular frequency, $\kappa (\nu) $, is obtained from oscillator strengths and photoionization cross sections. $\kappa (\nu)$ also depends on the photon-electron scattering. However, the total monochromatic opacity is obtained

from summed contributions of all possible transitions from all ionization stages of all elements in the source. Calculation of accurate parameters for such a large number of transitions has been the main problem for obtaining accurate opacities. The overall mean opacity, such as Rosseland mean opacity (κ), depends also on the physical conditions, such as temperature and density, elemental abundances and equation of state such in local thermodynamic equilibrium (LTE) of the plasmas. For plasmas under HED (high energy density) conditions, fluid dynamics may be considered for shock waves such as in a supernova explosion. The necessity for high precision calculations may be exemplified by some perplexing results for elemental abundances in the sun, Orion nebula etc. Recent determination of abundances of light elements carbon, nitrogen, oxygen etc are up to 30-40\% lower than the standard values long supported by astrophysical models, helioseismology, and meteoritic measurements. Laboratories can now study radiation transport or opacity in fusion plasmas, such as created by high power lasers beams in National Ignition Facility or by a Z pinch machine. The measurements will enable calibration of the theoretical calculations of basic parameters that govern the opacity.

Theoretical study of these relevant processes has made considerable progress under the Iron Project. We are able to calculate more accurate oscillator strengths for large number of transitions in relativistic

Breit-Pauli R-matrix method and find existence of extensive and dominant resonant features in the high energy photoionization cross sections not explored before. Inclusion of these features and more accurate oscillator strengths should provide more accurate opacities which can be used to investigate the astrophysical problems, such as solar abundance.

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