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Interdisciplinary Applications of Optical Spectroscopy on a Laser-Induced Plasma

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When a short pulse of laser light is focused to a small spot, the energy density may be high enough to ablate and partially ionize whatever material was in the focal volume of the laser (whether it was a solid, liquid, or gas.) This ionized gas plume can strongly interact with the incident laser pulse, quickly leading to significant heating and further ionizations, resulting in a high-temperature (50,000 K) micro-plasma, or "laser-induced plasma." As this plasma expands and cools over the course of microseconds following the laser pulse, element-specific spontaneous emission is emitted from the atoms that were present in the target material. A careful time-resolved spectroscopy of this spontaneous emission allows the quantification of the elements that were present in the target, a qualitative assay of the relative concentrations of a number of elements present in the target, and also provides a diagnostic of the plasma's time-dependent temperature and electron density.

In this talk, I will introduce the physics of this process and describe the current open questions and areas of investigation. I will also describe our group's efforts to use this real-time diagnostic assay of an analytic laser-induced plasma as a tool to rapidly identify pathogenic bacteria by measuring their elemental content; as a source of highly-excited atoms and ions for atomic physics measurements on elements of astronomical interest; and as a real-time diagnostic in a variety of other biomedical applications. Lastly, I will introduce the use of this technology on the Mars Science Laboratory rover "Curiosity" where it provides the underlying technology for the mission-critical ChemCam mast unit.

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