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Combustion: From a Jet Engine to an Exploding Star

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Abstract: Turbulent reacting flows are pervasive both in our daily lives on Earth and in the Universe. They power the modern society being at the heart of many energy generation and propulsion systems, such as gas turbines, internal combustion and jet engines. On astronomical scales, thermonuclear turbulent flames are the driver of some of the most powerful explosions in the Universe, known as Type Ia supernovae. These are crucibles, in which most of the elements around us from oxygen to iron are synthesized, and in the last 20 years they have led to one of the most remarkable discoveries in modern science, namely of the existence of dark energy. Despite this ubiquity in Nature, turbulent reacting flows remain poorly understood still posing a number of fundamental questions. In this talk, an overview of the numerical and theoretical work at the Naval Research Laboratory over the recent years is given, aimed at studying both chemical and thermonuclear turbulent flames. Several surprising phenomena that have emerged in the course of this work will be highlighted, in particular, in the context of the intrinsic instabilities of high-speed turbulent reacting flows, as well as some of the outstanding open challenges. Finally, the implications of this work for the development of the next generation of accurate, predictive turbulent flame models required for the design of practical combustion applications will be briefly discussed.

Biographical Sketch: Dr. Poludnenko received his Ph.D. in Physics and Astronomy from the University of Rochester in 2004. Upon graduation, he joined the Department of Energy ASC Flash Center at the University of Chicago as a postdoctoral researcher, where he worked on theoretical studies of astrophysical supernovae explosions and numerical modeling of thermonuclear deflagrations and detonations. Since joining the Naval Research Laboratory in 2007 first as a National Research Council postdoctoral fellow and later as a permanent research staff member, Dr. Poludnenko has been working on a wide range of topics in combustion, numerical algorithm development for hydro- and magnetohydrodynamics, and high-performance computing. In recent years, he has been leading the research program at NRL focused on theoretical and computational studies of turbulent combustion in chemical and astrophysical systems.

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