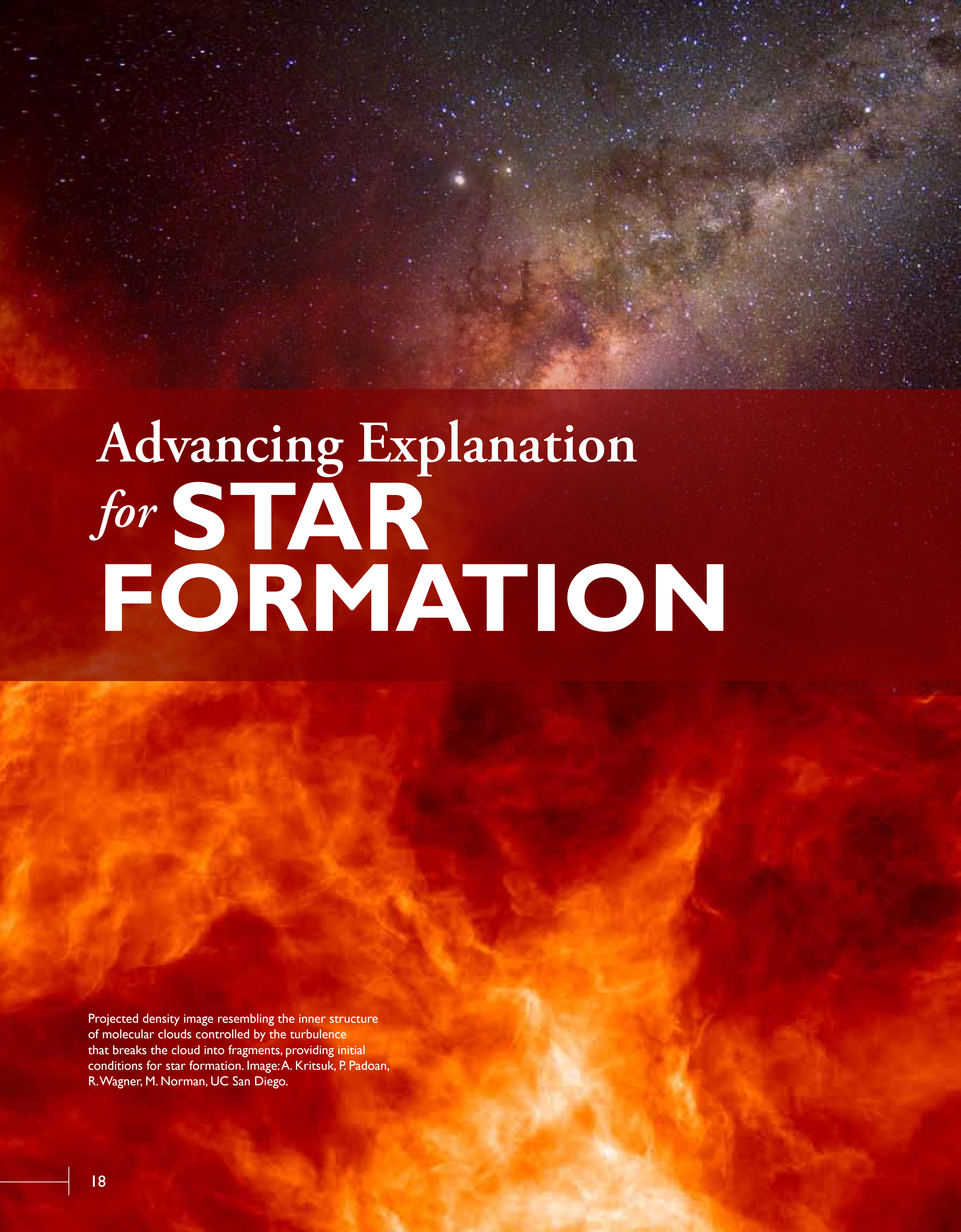

Advancing Explanation *for* STAR FORMATION

Projected density image resembling the inner structure of molecular clouds controlled by the turbulence that breaks the cloud into fragments, providing initial conditions for star formation. Image: A. Kritsuk, P. Padoan, R. Wagner, M. Norman, UC San Diego.

Alexei Kritsuk is a research physicist with UC San Diego's Physics Department and Center for Astrophysics & Space Sciences (CASS)

Insights gleaned from six supercomputer simulations of interstellar medium, at SDSC and elsewhere, last year confirmed principles in a seminal paper published in 1981 describing essential relationships of structure and motion in molecular clouds where stars form.

The new analysis, described in the October 2013 issue of the *Monthly Notices of the Royal Astronomical Society*—Great Britain's pre-eminent astronomy and astrophysics journal—provided for the first time an explanation for the origin of three observed correlations between various properties of molecular clouds in the Milky Way known as Larson's Laws, named for Richard Larson, now an Emeritus Professor of Astronomy at Yale University.

"After decades of inconclusive debate about the interpretation of the correlations among molecular cloud properties that I published in 1981, it's gratifying to see that my original idea that they reflect a hierarchy of supersonic turbulent motions is well supported by these detailed new simulations," said Larson in response to the new findings by three UC San Diego astrophysics researchers.

"This paper is essentially the culmination of seven years of research, aided by the use of large-scale supercomputer simulations conducted at SDSC and elsewhere," said Alexei Kritsuk, a research physicist with UC San Diego's Physics Department and Center for Astrophysics & Space Sciences (CASS), and lead author of the paper. "Molecular clouds are the birth sites for stars, so this paper relates also to the theory of star formation."

The analysis by the UC San Diego researchers is based on recent observational measurements and data from six simulations of the interstellar medium, including the effects of self-gravity, turbulence, magnetic field, and multiphase theramodynamics. The supercomputer simulations support a turbulent interpretation of Larson's relations, and the study concludes that there are not three independent Larson laws, but that all three correlations are due to the same underlying physics, (i.e. properties of supersonic turbulence).

Larson's original paper, published in the same journal, still inspires new advances in the understanding of molecular cloud structure formation and star formation.

The research team included Michael Norman, SDSC Director and a Distinguished Professor of Physics at UC San Diego; and Christoph T. Lee, an undergraduate researcher with CASS. SDSC's *Trestles* and *Triton* clusters, and now-decommissioned *DataStar* systems, were used to generate the simulations, as well as the *Kraken* and *Nautilus* systems at the National Institute for Computational Science (NICS) at Oak Ridge National Laboratory.

"None of these new findings and insights would have been possible without the tremendous advances in supercomputer simulations that allow not only cosmologists but scientists in countless other domains an unprecedented level of resolution and data-processing speed to further their research," said Norman, a globally recognized astrophysicist who has pioneered the use of advanced computational methods to explore the universe and its beginnings.

"We believe that this paper paints the complete picture, drawing from earlier published works of ours as well as presenting new simulations that have not been published before," Norman added.

Small Magellanic Cloud. Image credit NASA/CXC/JPL-Caltech/STScl.