Physics professor publishes exact solution to model Big Bang and quark gluon plasma

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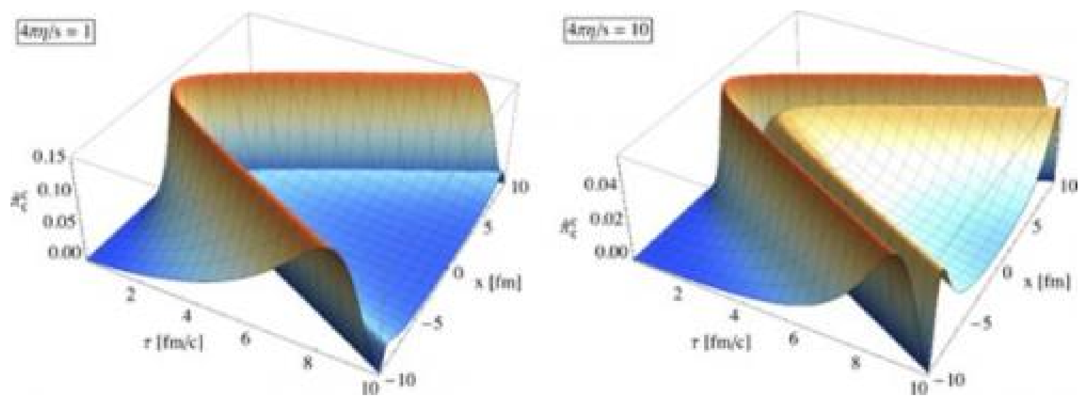

Credit: *Phys. Rev. Lett.* 113, 202301 – Published 14 November 2014.

Unlike in mathematics, it is rare to have exact solutions to physics problems.

"When they do present themselves, they are an opportunity to test the approximation schemes (algorithms) that are used to make progress in modern physics," said Michael Strickland, Ph.D., associate professor of physics at Kent State University.

Strickland and four of his collaborators recently published an exact solution in the journal *Physical Review Letters* that applies to a wide array of physics contexts and will help researchers to better model galactic structure, supernova explosions and high-energy particle collisions, such as those studied at the Large Hadron Collider at CERN in Switzerland. In these collisions, experimentalists create a short-lived high-temperature plasma of quarks and gluons called quark gluon plasma (QGP), much like what is believed to be the state of the universe milliseconds after the Big Bang 13.8 billion years ago.

In their article, Strickland and co-authors Gabriel S. Denicol of McGill University, Ulrich Heinz and Mauricio Martinez of the Ohio State University, and Jorge Noronha of the University of São Paulo presented the first exact solution that describes a system that is expanding at relativistic velocities radially and longitudinally.

The equation that was solved was invented by Austrian physicist Ludwig Boltzmann in 1872 to model the dynamics of fluids and gases. This equation was ahead of its time since Boltzmann imagined that matter was atomic in nature and that the dynamics of the system could be understood solely by analyzing collisional processes between sets of particles.

"In the last decade, there has been a lot of work modeling the evolution of the quark gluon plasma using hydrodynamics in which the QGP is imagined to be fluidlike," Strickland said. "As it turns out, the equations of hydrodynamics can be obtained from the Boltzmann equation and, unlike the hydrodynamical equations, the Boltzmann equation is not limited to the case of a system that is in (or close to) thermal equilibrium.

"Both types of expansion occur in relativistic heavy ion collisions, and one must include both if one hopes to make a realistic description of the dynamics," Strickland continued. "The new exact solution has both types of expansion and can be used to tell us which hydrodynamical framework is the best."

The abstract for this article can be found at journals.aps.org/prl/abstract/ … ysRevLett.113.202301 .

More information: New Exact Solution of the Relativistic Boltzmann Equation and its Hydrodynamic Limit, *Phys. Rev. Lett.* 113, 202301 – Published 14 November 2014. journals.aps.org/prl/abstract/ … ysRevLett.113.202301

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