Study reveals soliton solutions in Maxwell-Bloch systems

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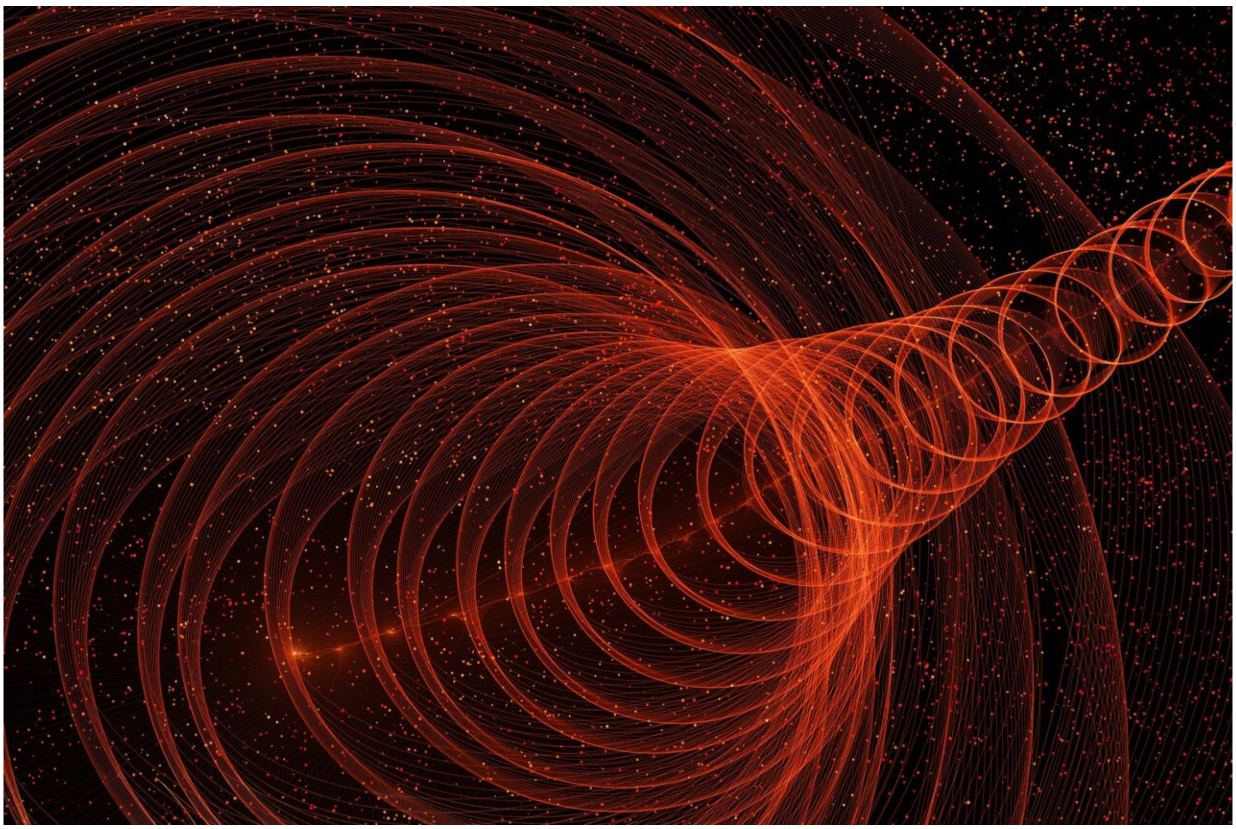

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Dr. Asela Abeya, of SUNY Poly faculty in the Department of Mathematics and Physics, has collaborated with peers at the University at Buffalo and Rensselaer Polytechnic Institute on a research paper titled

"On Maxwell-Bloch systems with inhomogeneous broadening and one-sided nonzero background," which has been published in *Communications in Mathematical Physics*.

Dr. Abeya explains that Maxwell-Bloch equations are foundational in optical physics, describing the interaction between electromagnetic fields and atomic populations.

Essential for modeling laser dynamics, these equations help explain critical phenomena such as super radiance, coherent population trapping, and optical bistability. They also provide insights into nonlinear optical effects like harmonic generation and soliton propagation.

By bridging classical and quantum realms, the Maxwell-Bloch equations are crucial for advancements in laser technology, quantum computing, and secure communications, as well as in exploring the profound dynamics of light-matter interactions.

The Maxwell-Bloch equations for two- and certain three-level media are completely integrable in the sense of possessing a Lax Pair (zero-curvature) representation, notes Dr. Abeya. Integrability makes it possible to more accurately linearize these equations via the Inverse Scattering Transform (IST) and enables the use of various transformation methods to "dress" simple exact solutions into more complicated and physically relevant ones, Dr. Abeya explains.

In this work, Dr. Abeya uses IST to solve the Maxwell-Bloch system corresponding to light pulses riding on continuous waves that are in the process of either turning on or off.

In this study, Dr. Abeya and peers show that the soliton solutions are always accompanied by radiation (existence of truncated solitons). Furthermore, the authors discuss the asymptotic state of the medium and certain features of the optical pulse inside the medium, and the emergence of a transition region upon propagation in the medium.

Dr. Abeya presented an invited talk on this significant result at the Society for Industrial and Applied Mathematics (SIAM) conference on Nonlinear Waves and Coherent Structures in Baltimore, MD, in June 2024.

More information: Asela Abeya et al, On Maxwell-Bloch Systems with Inhomogeneous Broadening and One-sided Nonzero Background, *Communications in Mathematical Physics* (2024). DOI: 10.1007/s00220-024-05054-y

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