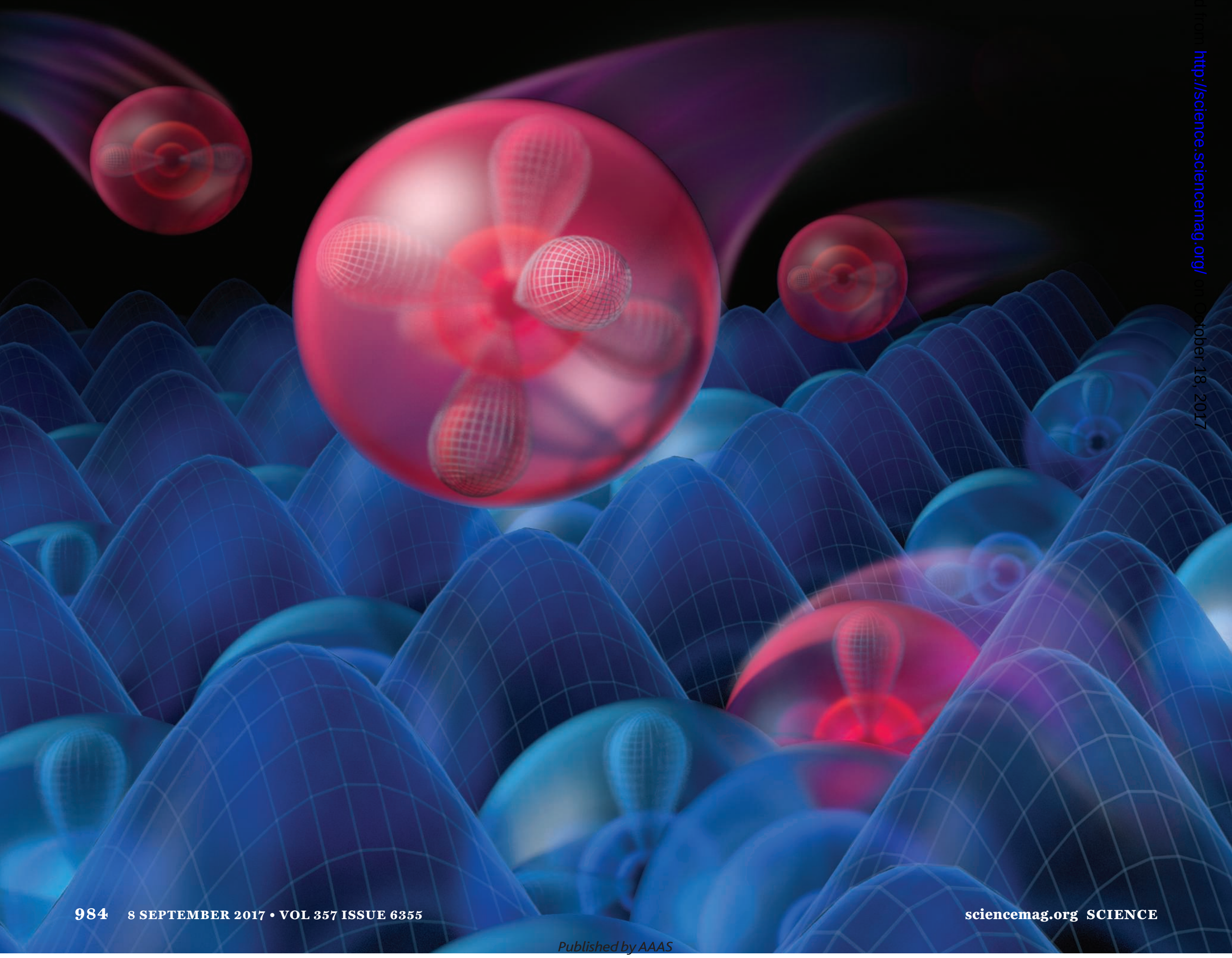
MANIPULATING ULTRACOLD MATTER

By **Jelena Stajic**, **Eric Hand**, *and* **Jake Yeston**



Atoms are dependably uniform—you would have a hard time, for instance, telling one rubidium atom from another. Many atomic properties have been measured to extraordinary precision: The frequency of an electronic transition in a cesium atom, for example, is used to define the unit of time. With atoms being so well characterized, it is possible to use them as probes—to look for tiny changes in their properties stemming from interactions with other atoms or the environment.

It helps if the atoms are extremely cold. When cooled to a fraction of a degree above absolute zero, atoms are easier to control, and their quantum properties come to the fore. More than 20 years ago, scientists cooled an atomic gas to the point where most of its atoms slumped to the lowest energy state, forming a Bose-Einstein condensate (BEC). Now, there are plans to send a small kit to the International Space Station, where researchers can create a long-lasting BEC to study the nature of matter and, possibly, gravity.

Back on Earth, physicists using the advanced tools of atomic and molecular physics have begun to address deep questions: What are the basic symmetries of the universe? Are fundamental constants actually constant? How do interacting particles form matter? What happens to molecules in chemical reactions? Although there are more traditional approaches to answering these questions—using particle accelerators, astrophysical observations, numerical simulations, and tools of condensed matter physics and chemistry—the extreme tunability and relative simplicity of ultracold matter experiments make them a compelling alternative.

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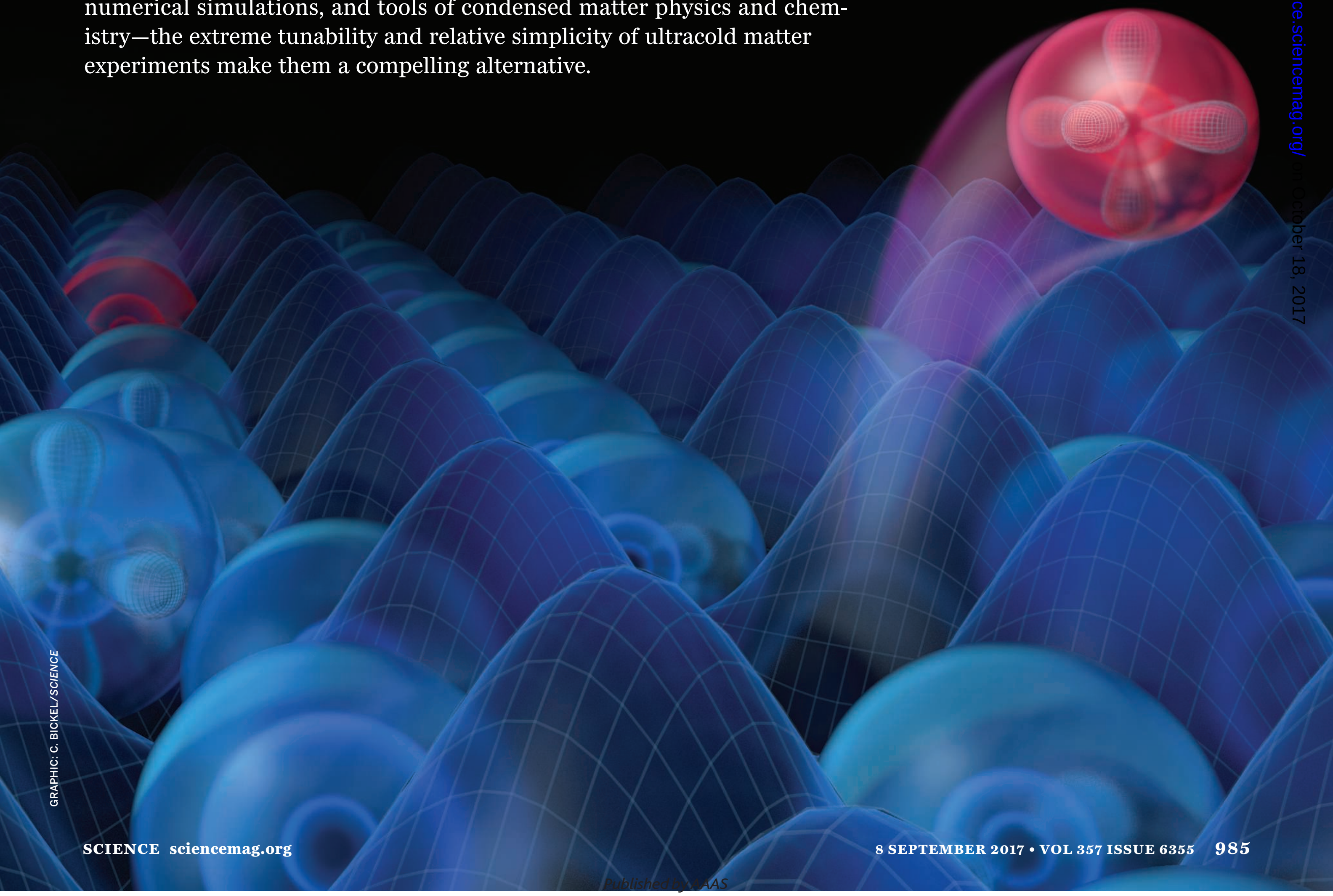

Artistic depiction of ultracold atoms (shown with atomic orbitals) loaded into an optical lattice. Blue and red respectively indicate frozen and mobile states.

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