nifty," says Bruce Margon of the Space Telescope Science Institute in Baltimore, Maryland, although he adds that the result will probably be controversial, because the measurements are extremely difficult.

If Lanzetta is right, the new findings have far-reaching implications for ideas about the formation of galaxies, among other things. Many galaxies may have formed early and rapidly instead of gradually, as most cosmologists have assumed. Such a fast-start scenario also would make it easier to explain why the early universe appears to have already been "polluted" with relatively heavy elements, which are produced in stars and then dispersed through space by supernova explosions.

Some astronomers are skeptical. Barry Madore of NASA's Infrared Processing and Analysis Center in Pasadena, California, who hasn't read Lanzetta's paper yet, says the results might be easier to swallow if there were independent confirmation. In fact, one unrelated study comes up with a somewhat different conclusion. Rodger Thompson of the University of Arizona's Steward Observatory in Tucson carried out a similar analysis using data from the Hubble Space Telescope's infrared NICMOS camera. His results point to a less violent beginning for the universe, with a star formation rate that stayed relatively constant for a couple of billion years before gradually tapering off. Thompson says the discrepancy might be due to subtle differences in the way the two teams corrected for the missing light.

Although Lanzetta says studies of distant quasars support his conclusions, he concedes that his analysis doesn't constitute definitive proof. But he hopes that future instruments such as the Next Generation Space Telescope and the Atacama Large Millimeter Array might see part of the missing light. –GOVERT SCHILLING

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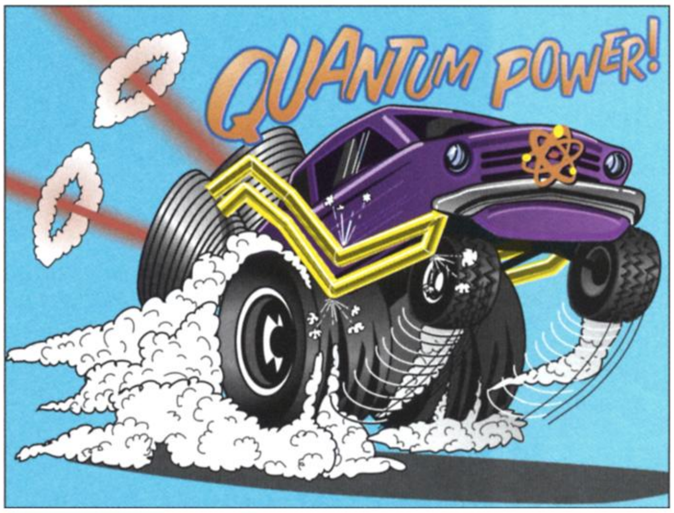
THERMODYNAMICS

Quantum Engine Blasts Past High Gear

All engines, whether the colossal thrusters on the space shuttle or the gasoline-fired power plant under the hood of your car, have to obey the laws of thermodynamics. Among other things, the laws set clear limits on the engines' efficiency: how much work they can squeeze from a given energy input. But take those classical axioms and add quantum mechanics, and unusual things can happen. Recently, Marlan Scully, a physicist at Texas A&M University, College Station, has discovered that in the quantum world, you can sometimes reap more horsepower than you'd expect.

Scully found that in theory he could take the hot exhaust from one kind of heat engine and drive a laser with it. Lasers work by storing energy in the internal quantum energy states of atoms or molecules and then releasing the energy in the form of photons. But heat engines generally ignore the internal states and instead harness the thermal motions of atoms and molecules in the "working fluid" (for example, the hot gas made by burning gasoline) as it expands and moves pistons to turn a crankshaft. The twist in Scully's scheme is to trade energy between the external and internal states of the atoms in a carefully choreographed way so as to squeeze a few more drops of work out of the engine.



CREDIT: ALAN "HOT-RODDIN' DADDY" STONEBRAKER

Overdrive. In theory, a quantum afterburner could supercharge a heat engine by turning exhaust energy into laser light.

In a paper accepted for publication in *Physical Review Letters*, Scully applies the concept to a type of heat engine called the Otto cycle, a cousin to the common car engine. Scully considers an idealized version of this engine without the exploding gasoline, instead just considering what happens as gas is compressed, is heated, does work, and is cooled again.

In his scheme, Scully takes the still-hot gas in the expanded piston chamber and routes it into a laser cavity, where the internal quantum states of the gas molecules come into play. The hot exhaust that would normally just be shoved out the door gets used to create more useful work by means of the laser emission. As a result, the total energy out is more than you'd expect from classical thermodynamic analysis of an "ideal" Otto cycle engine.

"I think it's a nice paper, very fun, and it's potentially useful," says Seth Lloyd, a physicist at the Massachusetts Institute of Technology. After hearing Scully give a talk about the concept, Lloyd dubbed the theoretical gadget a "quantum afterburner" by analogy to the devices that squeeze extra thrust out of the exhaust from a jet engine. "It takes advantage of a source of energy that hasn't been taken advantage of before," Lloyd says. After all, "the steam engine wasn't very useful until James Watt came along and made it more efficient. He didn't invent the steam engine, but he figured out how to control it."

Scully acknowledges that his analysis is controversial. But he says that doubters who once attacked him for flirting with perpetual motion have come around. "In thermodynamics, the devil is in the details, but so are the angels," he says. "You have to look at a specific physical system [such as the engine] and not just abstract thermodynamic calculations." Ronnie Kosloff, a theoretical chemist at Hebrew University in Jerusalem, agrees that Scully's concept is on solid ground: "It is consistent with all the laws of thermodynamics."

To check that his equations were on the up-and-up, Scully recently put his quantum afterburner to the ultimate theoretical test: hooking it up to an engine running at maximal efficiency. Until then, he had applied it only to the Otto cycle engine, which runs less efficiently than thermodynamics allows. But when Scully probed how well such a device would work with the ideal Carnot cycle, the gold standard of thermodynamic machines, the quantum afterburner couldn't squeeze out any extra energy—proof, Scully says, that his theoretical device is playing by the rules. –DAVID VOSS

GEOBACTERIA

Microbes Use Mud to Make Electricity

Self-recharging bacterial batteries that clean up organic pollution as they generate electricity? Sounds more like science fiction than science. But on page 483, microbiologists report coming one step closer to making microbial fuel cells a reality: They harnessed bacteria to generate electricity from underwater sediments. The microbes make excess electrons that they stick directly to graphite wires, which in turn send current to a second wire much like a car battery does. For fuel, the