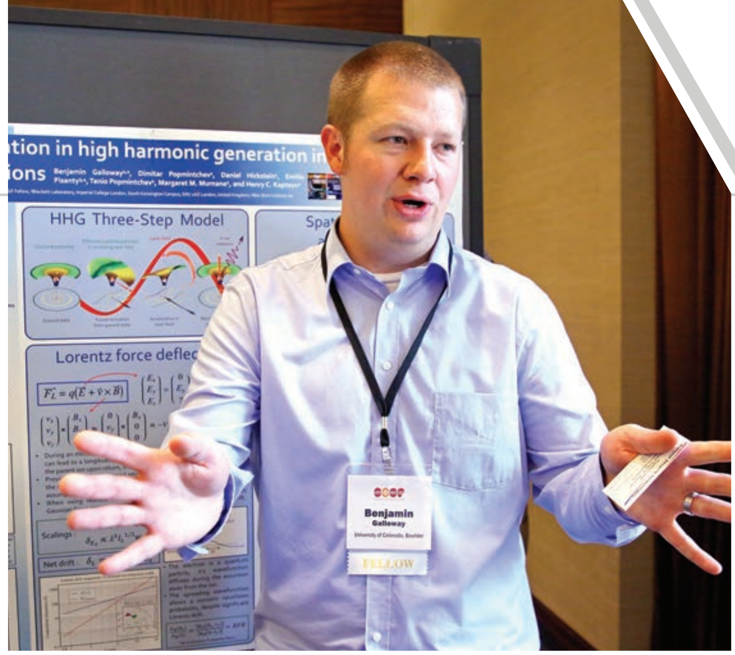

Laser Science Is Not Mad Science

BY BENJAMIN GALLOWAY

A blindingly bright laser shoots through a crowd of atoms. The laser is so bright that pieces of the atoms get ripped away, only to begin a performance of wiggling motions. While the tiny particles slosh to and fro, some of the atoms and their lost pieces rendezvous. There is a flash of invisible light – a signature of broken atoms made whole again – and it's all over. The dust settles. The world keeps rotating, the sun keeps burning, and people everywhere go about their lives without knowing there was a laser at all, let alone a turbulent sea of highly excited atom fragments in a laboratory somewhere.

What do scientists hope to achieve when they fire their powerful (and expensive) lasers at seemingly innocuous things, like the air? Who can benefit from their strange exploits? Who even cares? Indeed, the impact this research has on society is not clear at first glance. It may seem surprising that the process described above, called high harmonic generation (HHG), can help make computer chips smaller, medical X-ray exams less damaging to patients, and science research more efficient and accessible. That means smaller phones, less cancer risk and more clues to how the world works, which in turn leads to further advances to benefit society. HHG provides a means to achieve all of these goals by giving scientists and engineers a versatile tool: An X-ray laser.

To make an X-ray laser via HHG, scientists start with a more conventional laser with a reddish color. Firing this energetic light beam into a cloud of atoms causes those atoms to break into pieces, but it also gives them opportunities to reunite and release energy. As a result of these atom interactions, the red laser changes color drastically, from red to violet, and then hundreds or even thousands of times further, to outside the range of colors that the human eye can see. A far cry from where it began, the new X-ray laser can now pass through thick materials and reveal the fastest dynamics in the universe at the tiniest of scales.

It is difficult to grasp just how bizarre the HHG process actually is. Imagine a rainbow. Its beauty lies in all of the colors that it possesses – all of the colors that we can see. But the rainbow and its colors are really just an indication of what the sun provides. All of those colors were already present before water droplets redirected them toward our eyes, forming the rainbow. On the flip side, HHG allows us to start with light of a single color and make new colors that did not exist previously. Like a magician pulling a rabbit out of a hat – the rainbow represents a rabbit that was simply hidden until revealed, whereas HHG represents actually pulling the rabbit out of thin air.

In truth, magic and rainbows are glamorous analogies to HHG. The actual research laser scientists perform is challenging and sometimes messy. Numerous pieces of equipment must accompany a laser for it to work properly: water circulators, high-voltage power, vacuum pumps, gas lines – you get the picture. With so many working pieces, it's not uncommon for an experiment to halt because one of the components breaks down due to age, wear, contamination or electrical failure. Until all problems are fixed, no progress can be made. Laser scientists may be experts in laser science, but making repairs in a laboratory quickly teaches them to become proficient plumbers, machinists and electricians.

When every component functions and the X-rays shine bright, the real science can begin. By using such an exotic light source as a microscope, researchers can find new ways to examine and improve devices we interact with every day. The fundamental laws that govern nature can be investigated too – whether it's magnetism, heat transport, medicine, or chemistry, there's a chance to uncover something new, something never seen before, something worth writing about.

The beauty of nature can be seen outside in a rainbow or in the star-strewn sky at night, but it is also present in the mystery that governs atoms and light in a basement laboratory. As scientists, we are motivated not by some mad notion of world domination but by our pursuit of nature's beauty and its ability to improve the lives of others.

The author is a final-year fellow and the winner of the 2017 SSGF Essay Slam, an annual writing contest open to current and former fellows.