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A Comet Star

Growing up in the California desert, Qicheng Zhang developed an early appreciation for stars and the universal expanse beyond the sky. But his biggest space curiosity by far was with comets, those celestial bodies of ice, gas and dust, leftovers from the long-ago formation of stars and planets.

In high school, Zhang started writing software as a hobby and, naturally, turned to the sky for inspiration. His comet knowledge hit new heights through his development of a planetarium program, which required detailed information about a comet's location, direction and brightness.

"As far back as I can remember, I've always been interested in astronomy and astronomical events," said Zhang, now a fourth-year physics student in UC Santa Barbara's College of Creative Studies. "Comets are one of the few astronomical phenomena that you can just go out, say to Campus Point at UCSB, and see it, night to night, moving. Back in the 2013 the sungrazing comet ISON was so bright you could walk out in the morning and see its bright beam. That's so fascinating to me."

At UCSB, that fascination has been fostered into a research focus that is already paying academic dividends for the aspiring astrophysicist. Zhang spent his recent summer in a prestigious, comet-focused internship at the U.S. Naval Research Laboratory. Shortly after returning, he kicked off the 2016 academic year by publishing and presenting a paper, co-authored with UCSB physics professor Philip Lubin, to the SPIE Optics and Photonics conference.

And the honors keep coming.

Now Zhang has received the Thomas R. McGetchin Memorial Scholarship from the Universities Space Research Association (USRA), an organization formed in 1969 under the auspices of the National Academies of Science. USRA awards just five scholarships annually to undergraduate students who tackle challenging scientific questions in the areas of space research and exploration, particularly astrophysics and astronomy, and create technologies and solutions that will positively impact people's lives.

Zhang's award-winning work, and the focus of his aforementioned paper, examines the potential use of directed energy for comet deflection. Adapting and applying in a new way technology developed at UCSB by Lubin and his group for planetary defense against asteroids, and for relativistic spacecraft propulsion for interstellar flight, the undergraduate scholar demonstrated that a comet could be manipulated to mitigate a potential impact with Earth by heating it with a high-powered laser array.

"A laser is such a narrow beam that you can produce more power on the target than the sun provides, allowing an effective defense against comet strikes," explained Lubin, who heads UCSB's Experimental Cosmology Group and is Zhang's adviser. "It's not something to worry about right away, but it is noteworthy that we now possess the technology to protect humanity against another threat, comets, which is what some people believe may have decimated the dinosaurs.

"The system that we are building for our other programs, such as with NASA and the Breakthrough Starshot, is the exact same system Qicheng has now shown could be used for cometary defense with absolutely no modification," Lubin added. "What this reflects is that humanity has now advanced to the point of having mastery over certain threats in the solar system, giving us more control over our environment."

Most deflection schemes and the planetary defense community at large, Zhang noted, are focused primarily on asteroids and for good reason: "Because there are so many asteroids and because they are more likely to impact the Earth."

"But there are a certain set of objects — comets — that don't stay in the inner solar system where we can see them," he explained. "They come from far out in the distant reaches of our solar system and by the time we find them they could be well on their way to impact Earth. The whole purpose of this project is to come up with a

program that will enable us to prevent a comet impact."

Zhang's idea to explore such a scheme was inspired by comets themselves. The effect of heat on a comet's trajectory has already been observed, he said, courtesy of the sun, which "vaporizes the ices on a comet's surface and creates, essentially, jets on the surface of a comet that then push it in the opposite direction, so the comet accelerates away and deviates from its gravitational trajectory.

"The comet can't tell the difference between the sun or a laser shining on it, so it will behave the same way in either case," Zhang added. "We're using that knowledge to build a model of how large a laser we would need to move a comet enough to prevent an impact. The basic answer is that the same laser array the UCSB group proposes for spacecraft propulsion and for asteroid defense will work for comets.

"The threat of comets is of lower urgency than that of smaller but more common asteroids, from which impacts have been observed in recent history," he concluded. "Even so, given their unpredictable timing and the planet-scale disaster that likely follows impact, comet deflection remains an important consideration in planetary defense strategy."

About UC Santa Barbara

The University of California, Santa Barbara is a leading research institution that also provides a comprehensive liberal arts learning experience. Our academic community of faculty, students, and staff is characterized by a culture of interdisciplinary collaboration that is responsive to the needs of our multicultural and global society. All of this takes place within a living and learning environment like no other, as we draw inspiration from the beauty and resources of our extraordinary location at the edge of the Pacific Ocean.