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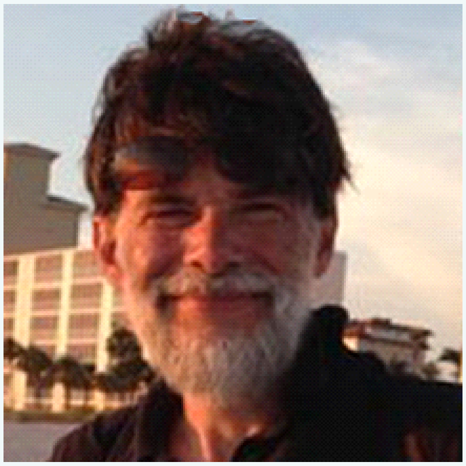
CONVERSATIONS WITH SCIENTISTS

Gianfranco Vidali: High-Risk Physics



Courtesy of Gianfranco Vidali

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Gianfranco Vidali is a professor of physics at Syracuse University in upstate New York. Born in Italy, Vidali earned a doctorate in physics from the University of Genoa in 1977 and completed a second doctorate in physics at Pennsylvania State University in 1982. Prior to joining the Syracuse faculty in 1984, Vidali spent two years as a postdoctoral researcher in the low temperature lab at the California Institute of Technology. Over the past 25 years, Vidali has been a visiting professorships at Princeton University, Penn State, the University of Hawaii, the Université de Cergy-Pontoise and the Observatoire de Paris.

Vidali is the recipient of numerous honors and awards, including an Alfred P. Sloan Fellowship in 1986. He has published more than 130 peer-reviewed articles, is the author of a book on the discovery of high temperature superconductivity, and has made frequent conference presentations. He is a regular reviewer for physics and astrophysics journals, an active member of professional organizations and university committees, and a dedicated cyclist and swimmer.

Vidali's research interests include "laboratory astrophysics (physics and *chemistry of the interstellar medium and of planetary atmospheres), surface physics, low temperature physics and chemical physics." Currently, Vidali's experimental research focuses on "studies of physical and chemical processes occurring in the interstellar medium and in planetary atmospheres" and the "characterization of structural and dynamical properties of surfaces." His theoretical research includes "atom-surface interaction, statistical mechanics of two-dimensional matter" and modeling of surface reactions.*

Below are Gianfranco Vidali's June 24, 2015 responses to questions posed to him by Today's Science. *Some of the questions deal with how he became interested in science and began his career in physics, while others address particular issues raised by the research discussed in Mystery of the Missing Oxygen*.

Q. When did you realize you wanted to become a scientist?

A. Later than most. Let me explain.

I grew up and received my education in Europe. Over there, and especially at the time I entered the university, the educational system was more rigid than here in the U.S., and changing one's field of study was not common. After entering the university, I had to decide on the discipline I wanted to get my higher degree in. If I chose physics, the program of study would require me to take only physics or science courses. If I chose philosophy, I would take philosophy and related courses, etc. Thus, it was an important decision to make, because it would set my career for the foreseeable future. On the plus side, high school education over there was and is much superior to what is available here. Although I graduated from a scientific lyceum (high school), I got a thorough background in the humanities (literature, philosophy, history, etc.) and the arts. Thus, after graduation I was torn as to what I wanted to get a degree in: literature, jurisprudence (constitutional law was appealing), or physics. My choice of possibly doing physics was inspired by the reading of a slim little paperback, *Magnets: The Education of a Physicist* by Francis Bitter. I am not sure why it made an impression on me, as I wasn't attracted to magnetism! Many years later I reread it. I couldn't see why it struck me as so special the first time through. But life is full of little things that have momentous consequences.

Q. How did you choose your field?

A. Physics seemed rigorous and yet it allowed plenty of room for imagination and creativity. Early on, I began working in a lab that was using helium atoms to probe the atomic structure of crystalline surfaces. I joined the lab because I was excited by what they were studying and thought I could contribute. The work was in the field of surface physics, or the study of the properties of — and processes occurring at — solid surfaces. Later I learned that that lab was one of only two labs in the world working with such novel technology. But many years afterwards, in the middle of my career, I no longer felt the same motivation. Instead, through a chance encounter at a conference, I learned that in astrophysics there were outstanding problems (specifically the formation of molecular hydrogen, the most abundant molecule in the universe) that could use some of the techniques that I had mastered. So after much reading, studying and writing proposals to federal agencies (mostly NASA), I began working in the field of laboratory astrophysics. Our measurements of the formation of molecular hydrogen on dust grain analogues in a simulated space environment were the first such measurements since the idea was proposed 30 years earlier. I am very grateful that the U.S. university system allows for career changes!

Q. Are there particular scientists, whether you know them in person or not, that you find inspiring?

A. Galileo Galilei, Richard Feynman, Lev Landau: not just excellent scientists but also persons of great moral and intellectual integrity. Physics tries to provide simple (and elegant!) explanations of natural phenomena. Feynman and Landau exemplify that. Galileo maintains a special place for having placed experimentation ahead of idle speculation and because of his moral rectitude. But there are many others.

Q. What do you think is the biggest misconception about your profession?

A. It is an old tale that if you want to get away from somebody at a party you tell him or her that you are a physicist. Such is the misconception. Most people associate physics with something difficult that they didn't understood while in school, and hence are afraid of people who were able to master it. Why such prejudice? Two reasons: one, teachers often teach physics poorly, and especially math, which is required to understand physics, because they never got to understand it themselves. Second, education is a two-way street; if people don’t put out enough effort and don’t have a strong will to motivate themselves, they will not get too much in return. Unfortunately, in this country you can graduate from high school — or even college — without any knowledge of physics or math. The results are in plain sight.

Q. As I understand, you found that the binding energy of oxygen on water ice and silicate was significantly higher than previous

experiments had determined. Why do you think the earlier efforts got this wrong? What did you do differently from previous efforts?

NASA

"Astronomical observations pointed out that molecular oxygen was not found in molecular clouds, the birthplace of future stars, or when it was, it was at much lower levels than suggested by simulations of the chemical composition of such clouds."

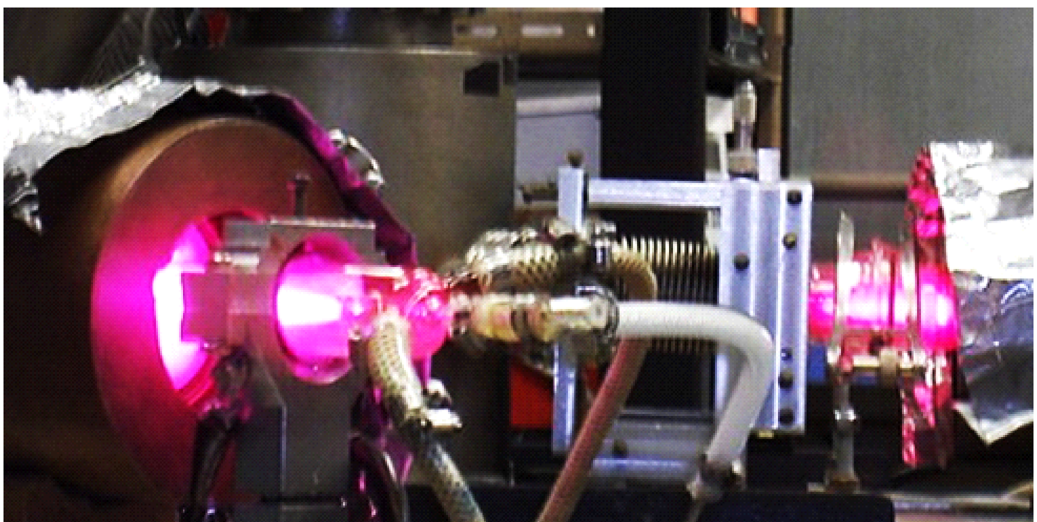
A. There hadn't been a direct measurement of the binding energy of oxygen atoms on dust grain analogs ("stardust") before we began our work. Rather, there were estimates based on theoretical arguments or indirect experimental evidence. Astronomical observations pointed out that molecular oxygen was not found in molecular clouds, the birthplace of future stars, or when it was, it was at much lower levels than suggested by simulations of the chemical composition of such clouds. As a way to explain this non-detection, some astronomers suggested that oxygen could be locked in stardust much more strongly than previously thought. My graduate student Jiao He, now a postdoc in my lab, and I realized that we could test this hypothesis. One important aspect of our work was to team up with a theorist, Michael Kaufman of San Jose State University in California, who was able to use our experimental data to generate a computer simulation of the chemical composition of a cloud.

Therefore, we were able to show astronomers and other theorists how our measurements affected the abundance of other chemical species in space, both in the gas phase and on grains.

Q. Your results explain why molecular oxygen is rarely seen in space. Are there other phenomena that are now understood because of your findings?

A. Oxygen on grains can react with hydrogen atoms (hydrogen is by far the most abundant element in the universe) to form water. It can be made to desorb from grains by ultraviolet photons. Once in the gas phase, it can react. These and other processes need to be re-evaluated because of the presence of oxygen on grains at higher temperature. The work has just begun.

Q. Are there other substances whose binding energy you feel it might be useful to look at — or re-examine? If so, which substances and why?



Courtesy of Gianfranco Vidali

"The work we do in the lab is intended to help astronomers and others make sense of their observations."

A. The decision on what to study depends on many factors. The work we do in the lab is intended to help astronomers and others make sense of their observations. So, in a way, we are guided by them. Of course it depends on whether you feel you can make a contribution with tools you have, and on your personal taste and, yes, on happenstance. The study of water, how water is incorporated into grains and then into planetesimals, is of interest to us because the question of how Earth and other solar system bodies received their water is not solved. Besides, water is intimately connected with the emergence of life.

Q. Was your study motivated by the desire to explain the astronomical puzzle posed by the lack of substantial amounts of molecular oxygen in space, or was there some other reason for your doing it?

A. As I mentioned above, our motivation is more general, i.e., to provide useful data that, when put together, lead us to a better knowledge of how our universe evolves. We realized from previous work that we were not only interested in this type of research (oxygen on grains) but also had a technique to do it.

Q. Where do you spend most of your workday? Who are the people you work with?

A. I spend most of my workday doing research and teaching my research students how to do research. This means actually working in the lab with my undergraduate and graduate students and postdocs, reading papers, writing papers and reports, evaluating somebody else's research proposals, working on committees to help my profession. I also do quite a bit of what I call outreach, or the fostering of an appreciation of physics and astronomy among the public.

Q. What do you find most rewarding about your job? What do you find most challenging about your job?

A. The most rewarding aspect is the act of discovery. It is satisfying to know that what you have done will help us understand the cosmos better. As I work with students on research projects, it is very satisfying to watch the blossoming of a young scientist right beneath my eyes. The most challenging aspect is not being able to marshal the needed resources.

Q. What has been the most exciting development in your field in the last 20 years? What do you think will be the most exciting development in your field in the next 20 years?

A. We are living in the so-called golden age of astrophysics and astronomy. This is due largely to the building of incredibly good ground-based and space-based telescopes. In the last 20 years, the finding of other planets and solar systems has given more impetus to search for habitable planets and for molecules that could be the building blocks of life. There are more powerful telescopes coming online or being built, such as ALMA (Atacama Large Millimeter/Sub-Millimeter Array) or the Thirty Meter Telescope, that should lead to exciting discoveries. There are also several robotic missions planned to Mars and to Europa, one of the satellites of Jupiter.

Q. How does the research in your field affect our daily lives?

A. Much of the research that my colleagues and I do is high-risk research; it means we often don't know the answer that we will get, or whether our efforts will be successful. Along the way, many things will be discovered or invented that eventually will benefit all of us. But there is no guarantee, That's why it is high-risk. And then there is the intangible gift of becoming excited by seeing how our knowledge and understanding of the world progress.

Q. For young people interested in pursuing a career in science, what are some helpful things to do in school? What are some helpful things to do outside of school?

A. Learning is a funny thing. While attending university, I remember sitting in an analytic geometry class. It was excruciatingly boring. Yet, now I retain more of that than when I was in another class taught by a charismatic teacher. So, the moral of the story is: apply yourself, not because you like something (which may be important, but is not necessary!) but because you need to learn it. Learn how to listen to intelligent ideas, and ignore the rest. And, away from the classroom, play. To develop creativity, play is important (and humor too).

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