香港大學
THE UNIVERSITY OF HONG KONG

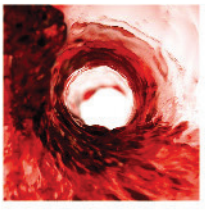
BULLETIN

October 2012 Volume 14 No. 1

MARVEL AT THE COSMOS

Discovering new secrets of the universe

The Magic of Red Wine
A natural remedy for oral health



Heralding a New Era
A glimpse of the new campus surroundings

Marvel at the **Cosmos**

HKU scientists are exploring the secrets of the universe and the origins of life by looking at stardust, the weird asymmetry of matter and anti-matter, and examples of Mars-like life on Earth. They are also pondering the messy impact that humans are having in space.

We Are **Stardust**

Discovery of complex organic matter in stardust may give clue to origins of life.

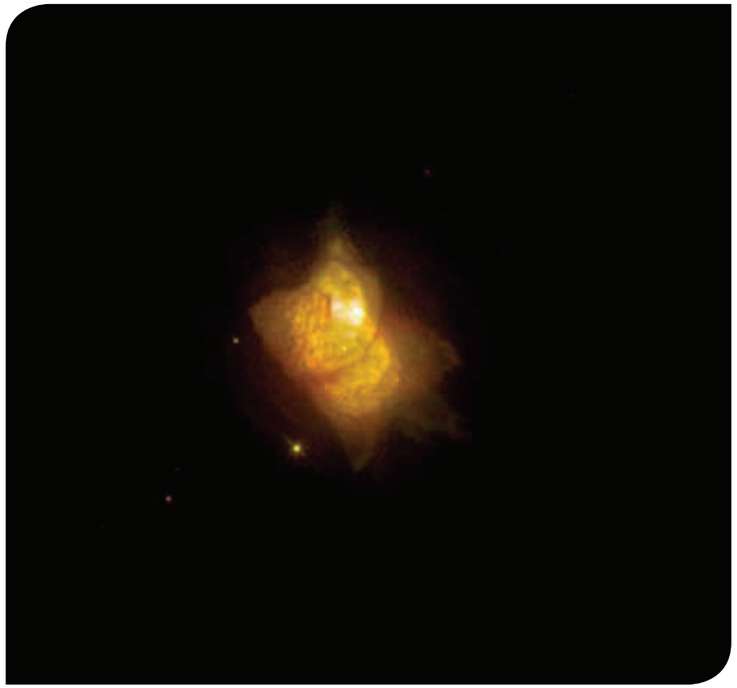
If Professor Sun Kwok had a dollar for each time someone had asked him "Is there life on Mars?", he would probably be a very rich man. It is the burden of every astronomer to be asked this question, usually in a not-too-serious way. However, recently, Professor Kwok, who is Dean of the Faculty of Science, has been giving a very serious answer.

"I am more optimistic than ever before that there is life elsewhere," he says. "Not aliens, but bacteria, micro-organisms."

His conviction springs from his discovery – made together with Dr Zhang Yong, Research Assistant Professor in the Department of Physics – that organic compounds of unexpected complexity exist in the stardust that is strewn across the universe by dying stars.

"So complex are these compounds," says Professor Kwok, "that they're similar to those that make up living organisms." The findings suggest that complex organic compounds can be synthesised in space and may even have seeded life on Earth and other planets.

Professor Kwok has done a great deal of research during his 30-year career into planetary nebulae (dying stars) and has long had a deep interest in stardust – small particles made by stars at the end of their lives and emitted across the universe.



The planetary nebula NGC 7027 is found to be manufacturing and ejecting complex organics at a high rate. This picture of the nebula was taken with the Hubble Space Telescope.

Infrared emissions

The new findings came about when he and Dr Zhang were studying the well-known but mysterious infrared emissions that are found in stars, interstellar space and galaxies. Collectively known as 'Unidentified Infrared Emissions', their existence is nothing new in scientific fields.

"When a star dies it ejects atoms, molecules, solids, we have long known about this," says Professor Kwok. "But in the past we thought it was simple inorganic matter. However, analysis of spectra of stardust – using infrared spectroscopic data – shows that these emissions contain a mixture of aromatic [ring-like] and aliphatic [chain-like] components, with chemical structures resembling those of coal and petroleum."

Understandably, this has sparked huge interest. The highly respected journal *Nature* reported the findings, and many other publications, both scientific and general interest, have picked up the story.

There has also been press coverage around the world, and it has only been fuelled recently by the landing on Mars of the United States' 'Curiosity' rover and the 'where-do-we-come-from?' sci-fi movie *Prometheus*.

"Our work has shown that stars have no problem making complex organic compounds under near vacuum conditions. Theoretically this is impossible, but observationally we can see it happening," says Professor Kwok.

The implications of the discovery are vast. Scientists have believed since the 1950s all things on Earth are derived from simple chemicals. The Miller-Urey Experiment (published in 1953 and considered to be the go-to origin of life experiment) simulated hypothetical conditions thought to be present on early Earth and tested for the occurrence of chemical origins of life – thereby showing that it was possible for life to have formed in this way.

From right to left: Professor Sun Kwok, Drs Scott Sandford and Yvonne Pendleton of NASA, and Dr Catherine Cesarsky, President of the International Astronomical Union (IAU), at the IAU Symposium on Organic Matter in Space, held in Hong Kong in 2008

> **"If stars can make such complex compounds, then the ingredients of life may be more common than we thought."**
>
> *Professor Sun Kwok*

"But if stars can make such complex compounds, then the ingredients of life may be more common than we thought, and that process of creating life may have been easier than we thought because complex compounds were involved, not just simple ones," says Professor Kwok.

"Life elsewhere"

"If stars can make complex compounds, and across the galaxy there are many, many stars ejecting this stuff, so some of it must have spilled into other stellar systems and other planets – so maybe there is life elsewhere."

These 'ifs' give rise to even bigger and increasingly intriguing 'ifs'. Says Professor Kwok: "If we found signs of life elsewhere, it would give us a second example biology – Earth being the first example. And, if so, will these other forms of life be similar to us or very different? If similar, how come? Do we share the same origin?"

"Then there is the whole major question of how did this stardust get into the Solar System and how did it reach Earth?"

One theory is that as the organic dust is similar to compounds found in meteorites it could have been carried in comets and asteroids that bombarded the Earth four billion years ago. Perhaps when Joni Mitchell sang "We are stardust. Billion year old carbon," she was nearer to the truth than she knew.

Professor Kwok, has recently been elected Vice-President of the International Astronomical Union (IAU)'s Bioastronomy Commission 51, which was held this year in Beijing. The IAU, which has 10,000 members worldwide, was founded in 1919 with the aim of promoting and coordinating the science of astronomy through international cooperation.

Professor Kwok was particularly thrilled that a surprise guest attended the event – China's Vice-President Xi Jinping. "None of us knew the Vice-President would be attending – his presence is a strong signal of China's commitment. I'm very excited about what's happening there, they have big plans to spend billions on astronomy – a billion alone on building a telescope in Antarctica. While Europe and the US may be growing more cautious in their spending at the moment, China has the commitment and desire to explore space." ■

The Gemini North Telescope under a starry sky (Courtesy of Gemini Observatory)

A Pilgrimage to **the Stars**

Professor Sun Kwok, Dean of Science, describes a night in the life of an astronomer.

As I step off the plane at Honolulu airport, I am greeted by warm tropical air and the smell of the sea. Sun-seekers give me a puzzled glance, wondering what this crazy guy is doing carrying a heavy winter coat in this tropical paradise. Indeed I am the odd man out as I am not heading to the beach, but to a dormant volcano 4,200m above sea level on the Big Island of Hawaii. I will need all the warm protection I can get in the subzero temperatures of the summit of Mauna Kea.

Mauna Kea, meaning 'white mountain' in Hawaiian for its snow-capped summit, is a sacred site for native Hawaiians. Mauna Kea is also a holy site of modern astronomy. It is the most popular location in the northern hemisphere to place large telescopes for astronomical research. A tropical inversion cloud layer forms around the mountain at about 600m, meaning the summit is almost always above the clouds, resulting in endless clear skies above.

I head up the mountain to Hale Pohaku, a mid-level (2,800m) facility for the observatories where I usually spend my first night trying to acclimatise to the high altitude. My students and I go over the star charts and observing plans, scheduling every detail of the coming nights down to the minute. This is necessary because at the summit of 4,200m, the decreased supply of oxygen can create acute mountain sickness including headaches, drowsiness, nausea, and worst of all for a scientist, impaired judgment. Since the cost of observing time on a telescope is valued at tens of thousands of US dollars per night, one does not want to make any mistakes or waste a single minute.

A steep climb

After a few hours of rest and breakfast around noon, I head up to the summit to check out the conditions of the telescope and the instrument I expect to be using. Too many times, I have found problems with a failed component, requiring me to make new plans. Sometimes, wind and snow on the summit intervene, creating endless anxiety that my precious observing time may go to waste.

The road between Hale Pohaku and the summit is mostly unpaved, steep, and winding, but once we reach the summit, we are greeted with the most spectacular sight of white telescope domes against a background of infinite blue skies. Among the largest are the two 10-metre Keck Telescopes, the 8.3-metre Subaru Telescope, and the 8-metre Gemini Telescope. After checking the equipment, I return to Hale Pohaku for a short dinner, then climb the summit again to start my observation.

I turn on the instruments, fire up the computer, and wait for sundown in the small and cramped operation room. This often is the most anxious moment because we will find out whether the instruments are working up to our expectations. If any problem develops, we put on our boots, gloves, and heavy coats and leave our heated control room for the naturally cold dome above. As the instruments are often hung on the telescope high above the ground, we use a 'cherry picker' to reach the boxes. Trying to fix delicate things in such clumsy clothing (and often in darkness) is not the easiest job.

Close up with the stars

If we are lucky, the problems are not major and observation can start. In the old days, one had to constantly guide the telescope to ensure it was not drifting from the target. Now, much of this tedious work has been automated and the computer does the guiding. Many of us still watch the screen for any signs of instrument malfunctioning or abnormal weather conditions. Will we detect anything? Are we going to discover a new phenomenon? Is my theory going to be confirmed? After the exposures are finished, we take a quick look at the raw, unprocessed data hoping for a glimpse of what we are looking for. Disappointment will mean an adjustment of plans. A new discovery will lead to excited cheers, hugs, and sometimes tears.

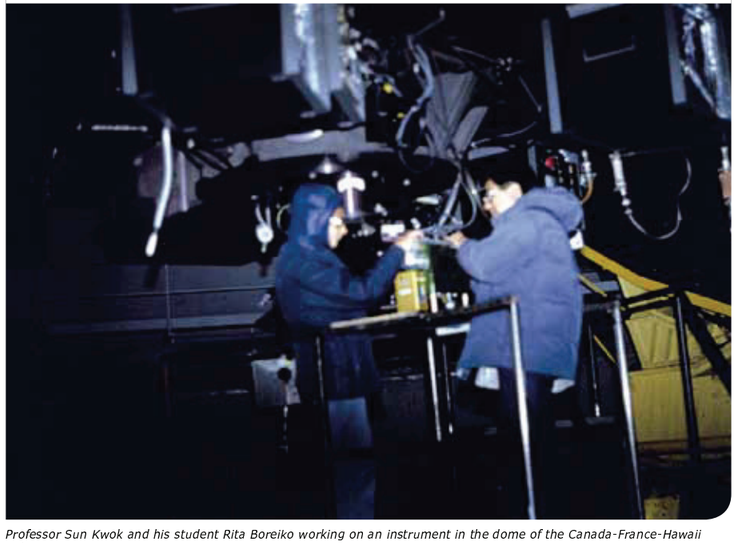
One of my favourite activities is to go out to the catwalk around the dome and admire the glory of the stars in the night. After allowing my eyes to adapt to the darkness (and this is total darkness as there is no artificial light anywhere in sight), I can make out faint stars that are hard to see among the light pollution of our civilised world and enjoy the majestic Milky Way. One has the feeling of being as close to God and nature as one can be.

When the dome finally closes with the dawn, I walk out of the building. The shadow of Mauna Kea is projected onto the distant sky by the sun at our back. Despite my tiredness and fatigue, this magnificent sight greatly boosts my spirits. Until I am too frail to undergo the vigour demanded of a night of astronomical observations, Mauna Kea will remain my Mecca and Jerusalem. ■

"Will we detect anything? Are we going to discover a new phenomenon? Is my theory going to be confirmed? Disappointment will mean an adjustment of plans. A new discovery will lead to excited cheers."

Professor Sun Kwok

The magnificent sight of white telescope domes (Courtesy of Canada-France-Hawaii Telescope Corp)



Professor Sun Kwok and his student Rita Boreiko working on an instrument in the dome of the Canada-France-Hawaii Telescope