MUOGRAPHERS 16

IM^{2}N Symposium

On May 9th, 2016, Wigner Research Centre for Physics (RCP) of Hungarian Academy of Sciences (MTA) and the University of Tokyo came together at the MUOGRAPHERS 16: IM^{2}N Symposium for the signing ceremony to mark the beginning of new collaborations in the field of muography through the Intellectual Property Cooperation Agreement.

The event, which was held at the Hungarian Embassy in Tokyo, began with a welcoming statement from H.E. István Szerdahelyi, Ambassador of Hungary as well as a brief history of the collaboration leading to the signing ceremony by Dr. Leonidas Karapiperis, Head of the Science and Technology Section of the Delegation of the EU to Japan. Representative professors from both Hungary and Japan also took time to address the audience on the range of facets that the signing ceremony covered, from an overview of Muography, organizational structures of the institutions affiliated and a brief overview of the potential applications that muography might have in the near future. The symposium culminated with the signing ceremony for the Intellectual Property Cooperation Agreement. Professor Peter Levai, Director General of Wigner RCP MTA signed with Professor Kazushige Obara, Director of the Earthquake Research Institute.

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The Science of Looking Deeper

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The solution comes in the form of muons, elementary particles produced by the collision of cosmic rays within the earth's atmosphere. These particles once produced radiate in all directions and can penetrate up to several kilometers of rock. However, they are able to penetrate less and less as the materials they travel through become denser. Scientists then are able to measure the number of muons coming from a particular direction on one side of a large solid structure, be it manmade or geologic, and develop images based on the different densities found in these structures. Muography then works on much the same principle as X-rays do when traveling through the body's tissues of differing densities to form an image of what is within.

A Vision Decades in the Making

The basic premise behind muographic imaging has been around since the 1950's when scientists performed experiments using radiation detectors such as Geiger counters to compare the amount of radiation that penetrates dense materials such as rocks and earth above underground tunnels. However, it was only within the last ten years that the technology to realize its potential as a practical (geologic) imaging tool came into the spotlight.

At the symposium Professor Tanaka explained the current technique behind Muography: " Since muons are generated in the atmosphere they are similar to rain, falling down to radiate every surface of the earth... So by placing a detector on the surface of the ground at the base of a [volcanic] structure, we can gather the muons which manage to pass through the object to see inside that structure." Being able to show proof of this concept was challenging however. While real-time muon detectors do exist, the necessary infrastructure needed to both power and deliver such a device into the field for testing has proven prohibitive.

Professor Tanaka's solution came in the form of a newly developed detector, consisting of layered plates of steel, lead and phosphor imaging plates, the last of which is capable of generating light when being struck by a charged particle such as a muon. These plates act as a type of film on which an image can be captured and subsequently developed at a later time. Development of these images came with help from Nagoya University, which created an automated system capable of scanning these plates for the captured muons. It was through this method that Professor Tanaka was able to produce the first-ever muographs of a volcano, Mount Asama located in central Honshu, Japan.

Seeing is Believing

The potential of such technology is not lost on scientists researching in other fields. Professor James Dohm of the University Museum, University of Tokyo, spoke at the symposium on behalf of friend and colleague Professor Hideaki Miyamoto of the same department. His presentation at the symposium comes on the heels of a muography exhibit at the University Museum in Tokyo on which both professors worked to demonstrate the underlying principles and importance of muography to the general public. Dohm is a planetary scientist whose primary focus is on the rocky planets of our solar system. Of particular interest to Dohm is the study of geologic structures on Mars, and how this new state of the art way of looking at internal structures can help us learn about our planetary neighbors.

"To be able to see inside large objects that we can't readily get into and explore very easily, muography gives us this opportunity in the same way doctors can now easily examine images of the human brain to make diagnoses... we are on the cusp, a wonderful new age of exploration." says Dohm. Using recently obtained imagery from the Mars Reconnaissance Orbiter, he drew the audience's attention to mysterious geologic structures dubbed mud volcanos as an example of a long standing question which muography can readily be applied too. All throughout the solar system there are large geologic structures that while similar to ones found on Earth are perhaps not formed or created by the same planetary forces found on Earth. But before the development of muography there was simply no way to study the interior structures of these and many other formations. Dohm's excitement for the new imaging method was palpable as he was keen to remind the audience of the growing number of applications stating, "Its such special time now to see these multidisciplinary and international efforts around muography, and the education and discovery that will come from it."

Dohm went on to elaborate not only about the uses of muography in his field of study but also on its uses here at home on Earth. While applications such as cave and mineral exploration were touched upon as a new way to map the structure immediately below the Earth's surface, it was shown that the technology is not only limited to natural structures, but man-made structures as well. Muographic images of the Fukushima Daiichi plant were able to show the extent of the internal damage at the facility at a time when it was too dangerous for humans to enter the area and examine the situation closely. "With muography, for the first time you were able to see the extent of the damage within the structures at the plant, which of course is a very important step in planning how to move in a hazardous environment." Dohm explained.

The Catalysts of Innovation

The growing number of possibilities surrounding this technology, as well as the technical challenges regarding its future development were also on the minds of those in attendance thanks to speakers Professor Peter Levai, General Director of MTA Wigner, and Professor Shigeo Kagami, General Manager of the Innovation and Entrepreneurship Division of the University of Tokyo. Both had a chance to speak about each side of the processes involved in the growth and development of new technologies, specifically muography.

Prof. Levai took the stage first to give the audience an idea how his institute is organized and the basic economics regarding the type of research that was on display throughout the symposium. Levai explains, "It is becoming increasingly important to the average citizen that through our science there can be a benefit directly applicable to society... and a very good example of this would be the ability to predict something as important as a volcanic eruption." The effects of volcanic activity are something the general public is seeing more of in the news rather than in geology and history textbooks. Events like the 2010 eruption of Eyjafjallajökull in Iceland, while relatively small in scale caused an enormous amount of disruption to travel in northern and western Europe with the effects subsequently felt in the economy and day to day lives of average citizens. This is also something Professor Tanaka is keenly aware of living in Japan where there are many active volcanoes. The eruptions of these volcanoes as well as the seismic activity that accompanies them can have a devastating impact on those living on the islands of Japan. The reality of living under such conditions was highlighted as a key benefit of joint research for the continued development of muography.

But while there are very clear uses for such technology both in science and industry Professor Levai was also quick to note that one of the largest challenges for scientists to contend with is the funding that makes such breakthroughs possible. Levai gave a comprehensive breakdown of how funding is allocated at his institution, Wigner MTA. This was done to share with Japan how different funding models can lead to successful cooperation through continued research as well as how collaboration can enhance this process. "It is necessary for us to look at what others are doing and then the fundamental structure of our institutions for how we can be more efficient when it comes to accountability, research , feasibility, potential services and its costs." says Levai, adding that " developing new strategies involving research partnerships with other institutions and universities with similar interests is key."

Levai made a point during his speech to praise Japan with regard to its progress in the development of intellectual properties that come about through university research, outlining why cooperation was key to minimizing institutional costs while maximizing brainpower by overlapping fields of research. To elaborate more on this Professor Shigeo Kagami outlined the function of the Entrepreneurship Division of the University of Tokyo, and how divisions like it foster not only the kind of new financial opportunities previously alluded to by Levai, but also interest in industry which can find new and novel applications for muography. One example given was its use for measuring the size and density of glaciers around the world to study the effects of global warming.

Looking Towards the Future

Speaking last at the event to drive home not only the finer points of his life's work, but also the importance of this symposium, Professor Tanaka reflected on the technical challenges that still must be overcome for the next generation of muography. "Currently the technique used to source images of volcanoes is resolved over time. What we have to do is clear. We need to be able to get images like these in real time. " explained Tanaka. " This will be possible during the next generation of muography, using many detectors in an array together to increase the detection area and amount of muons gathered". This is similar to how multiple satellite dishes are built together in clusters to increase the imaging power available to astronomers. However, Tanaka was quick to point out however that with detectors at their current level of technology this method of real time muographic imagery is prohibitively expensive, and that such detectors would be incredibly heavy, (weighing close to twenty tons) making them difficult to transport to the locations necessary for observation.

The dream of realizing muon detection technology light enough and cheap enough to see practical use in real time volcanic observation is something Tanaka sees being made possible through a global muography network. The Earthquake Research Institute of the University of Tokyo is already moving forward with a project between seventeen different institutions across six countries. The goal of the project is to produce a global standard for detectors which are not only applicable to volcanic research, but also to other fields of study that were represented by other guests at this event.

To emphasize the importance of projects like this and the tangible gains made possible by the signing of the cooperation agreement during the symposium, Tanaka showed the audience two photographs to display the state of muography detectors today. One image showcased the detector used to successfully image volcanoes in Japan being moved by cranes, where the other picture was of a piece of detector equipment being developed in Hungary which was being held up by a single person. The Hungarian example was stated to be not only lighter, but in its current state is also twice as cost effective. Tanaka added, "If we can combine these two independently developed technologies to create an optimized system, many previous possibilities become realistic."