The International Congress of Basis Science – A Melting Pot of Ideas

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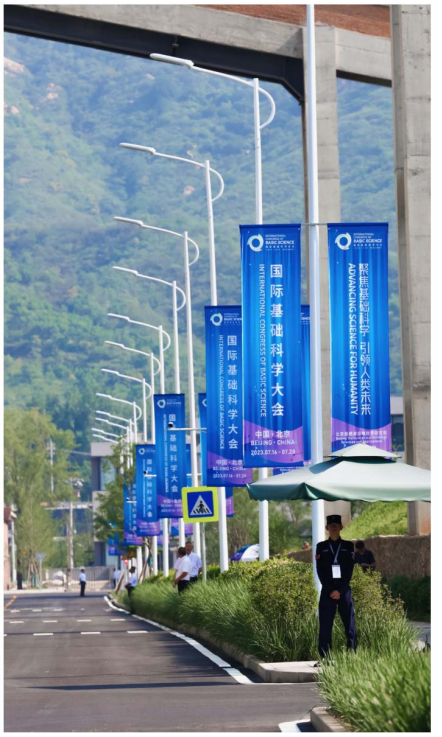
The first International Congress of Basic Science (ICBS) took place in Beijing from July 17th to July 28th 2023. It featured more than 1000+ participants from all over the world and 300+ talks. A gigantic event with many superlatives planned and executed within just eight months. The organizing committee faced many obstacles: though international travel resumed by end of 2022, flight schedules were far from the pre-pandemic level; the hosting institution, the Beijing Institute of Mathematical Sciences and Applications (BIMSA), just moved into completely new facilities mid-May. Many obstacles, but probably the most fascinating part of China is that everything worked out just at the moment it was supposed to do so.

If any participant thought it would be an ordinary math conference, just a little bigger, they were convinced the contrary the moment they landed at the airport.



Huge help-desk signs, busses and limousines for picking up the participants, and flags of ICBS all the 50 km from airport to any of the three residence hotels, on every lantern on both sides of the streets hinted at something extraordinary. The opening ceremony happened at the People's Hall. A marathon event, requiring unimaginable amount of detailed planning and joint effort. It started with an obligatory PCR test the day before, included getting formal invitations and badges ready for every participant during the night, and coordination of the trip the next day convoy of 16+ busses and a few more limousines at six in the morning. The highway was blocked just for our convoy, no rush hour was interfering with us arriving at the Great Hall on time.

The ceremony itself was rather an outreach event, with everything choreographed up to the minute and many official pictures taken, press conferences held, interviews conducted. Two Basic Science Lifetime Awards (BSLA) and 144 Frontiers of Sciences Awards (FSA) were given out.

When the duty was done, the Gala dinner followed, with amazing food that was served at all tables at once, and with beautiful performances showcasing ancient Chinese culture. The guests were delighted, the organizers relieved that everything went so well all day. With the bus convoy on empty streets of Beijing back to the hotels the first day ended.

The scientific conference started on Monday July 17 with three Basic Science Lectures given by the two BSLA winners David B. Mumford and Adi Shamir, and the 2018 Fields Medalist Alessio Figalli. Three very different subjects, one on neu-

roscience, one on Image recognition, one on PDE. Even for the most experienced speakers, the huge stage and the 1000+ people in the audience must have been very special. The three did a fantastic job explaining their research to a mostly non-expert audience. These talks set the right tone for the whole conference, as cross-disciplinary collaboration is only possible if experts make the attempt of explaining difficult things in a simple way. As an example, let us dive into the talk of Adi Shamir:

Manifolds in Machine Learning

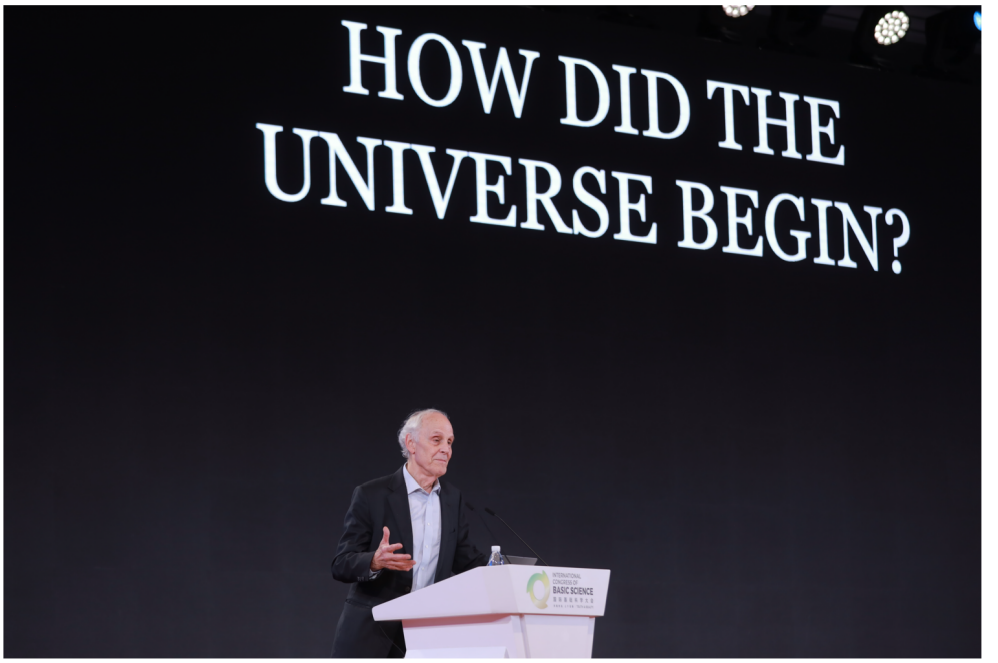
In his talk the Basic Science Lifetime Award recipient Adi Shamir (of RSA fame) discussed intriguing research on the nature of so-called adversarial examples (see [1], [2]) in deep neural networks. In the context of image classification, adversarial examples are minute changes to input images which, while imperceptible to humans, cause otherwise highly-accurate deep neural networks to give wild (and almost arbitrary) misclassifications. Amusing examples shared by Shamir in his talk include a picture, clearly of a cat, classified as guacamole, and another picture, clearly of a pig, classified as an airliner.

A standard attempt at explaining adversarial examples shared by Shamir is as follows. In the very high-dimensional space of all possible input data, the neural network constructs boundary surfaces separating distinct training data. Adversarial examples are then supposed to be instances of perturbations pulling images across this boundary, in the direction of a cluster of training data of a different category. While presenting a clear conceptual picture, this model, according to Shamir, is completely untenable: crucially, adversarial examples can turn *anything* into *anything else*, and can do so by very small perturbations, while the training data is much more well-separated (normal pictures of guacamole, after all, are not at all close to the adversarial cat-guacamole examples!).

Shamir described research aimed at supporting a very different explanation for adversarial examples. First, one considers that all "real" images lie on a submanifold of the full image space which has very high codimension. Shamir then suggested that a neural network, in constructing a decision boundary, first produces a submanifold closely approximating this high-codimension "real" image submanifold, and then refines it to accurately separate the training data by introducing "dimples". This results in a decision boundary which, while accurately representing the training data, is nearly *parallel* with, rather than transverse to, the submanifold of "real" images. To put this another way, the suggestion is that the training process for neural networks, by its very nature, results in a classification where all of the training data lie close to the decision boundary. (A good example would be using the graph of $\epsilon \cos \pi x$ as a decision boundary between even and odd integers.) Thus, very small perturbations (especially those transverse to the submanifold of "real" images) can easily cross the decision boundary, giving an incorrect classification.

While the data sets used to train image classification neural networks are of course far too high-dimensional for the suggested phenomenon to be visualized directly, Shamir demonstrated his proposal to us by showing images and videos of neural network training on two- and three-dimensional data. These provided striking and compelling confirmation of his hypothesis that the decision boundary first evolves to approximate the data, and then evolves slowly to form "dimples" around the distinct data points.

The huge LED screens, probably a little too bright, so that some in the first rows actually wore sunglasses to follow the talks with white background slides.



Coincidence or not, David Gross' slides the next day at his Basic Science Lecture during Physics night had black backgrounds.

It was an immense amount of people. The most notable were students from Qiuzhen College of Tsinghua University in their red polo shirt uniforms. This college, established in 2021, has the mission to educate the next generation of world class mathematicians in China. It consists of hand-picked and particularly gifted students, some them just 14 years old. They are at the conference to feel the international flair and to experience what world class research looks like.

For the next two weeks, busses were commuting between the hotels and the BIMSA campus in 20 min intervals. They dropped the participants in front of a

gigantic 3×4 meter wall with the complete schedule of the conferences printed out. The mornings started with talks of very senior researchers, like Fields Medalists, Turing Prize winners while the afternoons were mostly designated for Frontier of Science Award winners, in up to 10 parallel sessions, spread all over the huge BIMSA campus. With carefully drafted maps and signs and volunteers and help-desks in every building, the participants were guided to each lecture room. All talks, if the speakers consented, were broadcasted, and recorded. To ensure that everything ran smoothly, tech support was available in every lecture room. Yau himself was also often spotted in lectures where he was, always a never-ending flow of tea.

After talks there were many gala events. The first day was dedicated to BIMSA's official opening. Then we had Physics night, Math night and CS night in the successive evenings, with performances, dinners, and wine. These events created many occasions for the participants to interact and have fun together in the evenings. Even weather favored the conference. Despite the original forecast with nine days of rain, we had sunshine for most of the two weeks. Except for the weekend, when tours onto the Great Wall, the Forbidden City and the Summer Palace were taking place, summer rain set in.

What is the takeaway from such a huge and diverse conference? I personally enjoyed the interviews we conducted for the ICCM notices, I loved going to a random lecture room and listen and learn something completely outside my field, in my case machine learning, statistics, and quantum algorithms. The conference was a huge collective effort, but that is also how a new institute like BIMSA

grows together. We all have a lot of stories to tell from being part of it. As the preparations for the 2024 ICBS are already in full swing, I look forward to meeting the next BSLA and FSA winners and all other visitors.

References

[1] B. Biggio et al., *Evasion attacks against machine learning at test time*, Machine Learning and Knowledge Discovery in Databases (H. Blockeel, K. Kersting, S. Nijssen, and F. Železný, eds.), Springer, Berlin, 2013, pp. 387–402.
[2] C. Szegedy et al., *Intriguing properties of neural networks*, 2013.