

Playing with Einstein

*Stefano Oss¹, Luigi M. Gratton¹, Silvia Defrancesco¹, Fabrizio Logiurato¹,
Beniamino Danese^{1,2}, Christian Lavarian³, Lavinia Del Longo³, Marilena Grifò³,
Roberta Guardini³, Michele Lanzinger³*

¹ *Physics Department, University of Trento, Povo (TN), Italy*

² *IPRASE, Trento, Italy*

³ *Museo Tridentino di Scienze Naturali, Trento, Italy*
guardini@mtsn.tn.it

Introduction

One hundred years ago, Einstein made an exceptional contribution to modern physics by publishing a number of articles that became milestones in the history of physics. To celebrate this marvellous year, the United Nations designated 2005 as the “World Year of Physics”. A decision that gives recognition to a discipline that is essential to scientific and technological development, and promotes endeavours to bridge the gap between physics and non-experts. In response to the United Nation’s designation, many museums and other scientific institutions organized events for the public on the topic of physics. In this spirit, Museo Tridentino di Scienze Naturali and the Physics Department of the University of Trento developed the interactive temporary exhibition “Playing with Einstein”.

Guided by Albert Einstein’s quotations from his “Scientific Autobiography” [1] visitors can explore physics at the turn between the XIX and XX century to share his wonder for the natural world and to marvel at the revolutionary theories that the scientist formulated in many different fields of physics.

They may contemplate, through the eyes of Einstein, how scientific thought evolved in those very special years: in so doing, they come to terms with the difficulties and mysteries which are the main stimuli of researchers.

“Playing with Einstein” is the result of the synergic cooperation between Museo Tridentino di Scienze Naturali and the Physics Department of the University of Trento, who combined their different skills during the concept, development and construction phases.

The exhibition opened on March 12th 2005 and was expected to close on October 30th 2005. But the date of closure was postponed to the end of January 2006, due to the many requests made by schools.

The exhibition itinerary

Based on the hands-on philosophy, the exhibition is a place where adults and children “can touch, play and experiment with the exhibits” [2]. Aided by explainers, adults and children – as new scientists – are stimulated to experiment and think about the whys and wherefores of the things [3]. Written explanations on labels have been reduced to the essential and insight into the more complicated aspects is provided in the form of computer simulations that are placed next to the exhibits.

The exhibition set-up is organized in six spaces which represent significant moments in the history of scientific knowledge. Not just moments related to Einstein. His genius without doubt marked for all time the evolution of knowledge and our understanding of the Universe. But it is important not to forget the contributions of dozens of other scholars, scientists,

inventors, and passionate devotees who, together, passed through these periods of doubt, questions, hypotheses, and theories.

The journey starts in the courtyard of the museum where a train and a rotating platform provide an introduction to Galilean relativity of motion and inertial and non-inertial reference systems. On the train visitors throw a ball in the air and catch it in a net to see that their linear uniform motion does not affect the ball's downward motion, and thus that nothing in the ball's behaviour gives away the fact that they are not sitting still with respect to the ground (Fig. 1).

On the rotating platform two or more people roll a ball towards each other and notice that to them it bends instead of moving in a straight line. However to watchers that are observing the scene from outside the ball appears to go straight, while it is the table that rotates beneath it (Fig. 2).



Figure 1



Figure 2

Inside the museum, visitors first encounter a large panel of pictures, documents and short texts which present the many different facets of the Einstein's personality, reminding us that his contributions were not limited to science [4].

The main part of the exhibition is then entered: the first section shows XIX Century physics through toys such as spinning tops and rolling cylinders (Fig. 3), set in a room which could have been Einstein's own as a child and which also contains the compass (Fig. 4) and examples of Euclidean geometry that had struck the scientist at an early age.



Figure 3



Figure 4

The sense of wonder increases in the second section, dedicated to light. There are mirages, lasers, prisms... The question "what is light?" begins to be tackled, with a first tentative answer suggested by the comparison between interference patterns and the ripples that form on the surface of water (Fig. 5).

This hypothesis gains confidence in the third section of the exhibition, where electromagnetic phenomena are presented in greater detail. So we have a large-scale version of Oersted's experiment, a simple setup of Faraday's law (Fig. 6), a television with a remote control to experiment with.

The hypothesis on the wave-like nature of light receives a serious blow in the next section, dedicated to the phenomena that XIX physics could not explain: the distribution of energy among different wavelengths for blackbody radiation (Fig. 7), the structure of matter and its interaction with light, the photoelectric effect and the Brownian motion.



Figure 5



Figure 6

In this section visitors come into contact with the non-intuitive phenomena of modern physics and begin to make acquaintance with Einstein's own contributions, by interacting with exhibits grouped in pairs. In his explanation of the photoelectric effect, Einstein regards light as a stream of "energy packages", called quanta. In the dedicated exhibit (Fig. 8) the visitor simulates the expulsion of electrons from a metal, illustrating the basic concepts of the photoelectric effect. Close by, a "lab-like" experimental setup illustrates the actual phenomenon.



Figure 7



Figure 8

A macroscopic model of Brownian motion is reproduced by means of ping-pong balls (Fig. 9). A microscope at its side allows to visualize the true Brownian motion of rubber microparticles suspended in water.

Using a similar approach, reproductions on panels and three-dimensional models illustrate the history of atomic models, while the same topic is presented more playfully using a game

of minigolf that simulates the experiment that allowed Rutherford to discover of the structure of the atom (Fig. 10).



Figure 9



Figure 10

The final part of the exhibition is devoted to Einstein's special and general relativity: a relativistic bus takes visitors on a ride to discover how the world would look if we travelled at a speed close to that of light (Fig. 11).



Figure 11

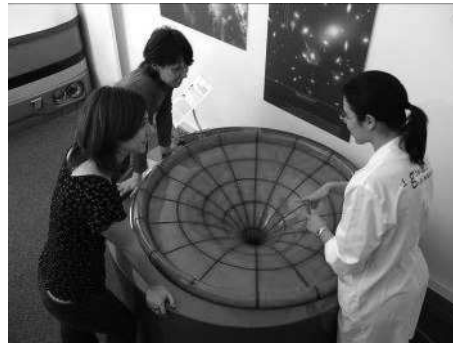


Figure 12

In Einstein's theory of gravity, the effects of gravity on the motion of bodies are described by a deformation of space-time geometry. A Funnel-like device with balls that roll represents a model of the motion of planets (Fig. 12).

Visitors may proceed to learn about current-day physics research in Trento in a poster display that illustrated the work carried out at the Physics department of Trento University and at the Institute for Research in Science and Technology (ITC-irst).

Educational Programmes

Teachers of the three Italian school levels – elementary, middle and high – gave their support to define the educational activities linked to the exhibition, with proposals targeted to the three different age groups.

The educational programmes include guided visits to the exhibition, an option chosen by almost all visiting teachers. Furthermore, groups are given the opportunity to end their experience in a “follow-up session”, with support material to encourage students to comment on the exhibits seen and on the discoveries made in the exhibition. Teachers may conduct these sessions autonomously or request the support of an explainer.

High school students may also assist physics lab demonstrations of the photoelectric effect, diffraction phenomena or spectroscopy.

Lastly, the exhibition development team gave guided visits for teachers of the different school levels in the three days immediately following the exhibition opening. These were greatly appreciated by teachers, with over 200 of them attending.

The guided visits and the additional activities are conducted by explainers. There is a team of 25 explainers specifically for the exhibition. These are students of physics, mathematics and engineering who passed a selection that the museum made two months before the exhibition started and took part in a preliminary training session that lasted 20 hours. The group of teachers that took part in the development of the educational activities also participated in the explainer training and went through the exhibition with the explainers to illustrate to them the different approaches devised for the three target groups and to provide insight on possible links between the exhibition content and school activities.

From March to August 2005, outreach activities were organized to promote the diffusion of scientific culture. These started right after the exhibition opening in March, with a “relative birthday party” in which anyone could celebrate their birthday together with Albert Einstein’s stunt man and continued with many different events: from scientific theatre, to shows in the town square, to workshops for families, science cafés...

Conclusions

Although the quantitative data (questionnaires that visitors can fill in on a voluntary basis at the end of the visit) is still under evaluation, we can already say that the exhibition has been a success, with many teachers booking repeat visits with different classes.

Visiting students (at end of school year '04 – '05) were over 11.000, with 596 school groups in total. The total number of visitors, after six months from the opening, is of over 45.000, whereas the participants to special programs were over 6.500.

We have gathered many positive comments on the exhibition in general, as well as some negative comments regarding the fact that the exhibition space is too tight. The lack of space is a general problem in our museum, which we hope to solve once and for all with the opening of the new science museum in Trento which is due probably by the end of 2009.

But what can we say more specifically about the relationship between visitors and physics through the exhibition?

One first important point – from the overall number of visitors – is the fact that people are willing to come and visit an exhibition on physics. The comments left at their exit show that they also appreciate the exhibition as a whole.

From interviews with the explainers we find that the interactive aspect of the exhibition is much appreciated by the visitors. As we also found in previous exhibitions, the most popular exhibits are the ones in which the visitors are most involved: the rotating platform, the train, the relativistic bus... so ones with which the visitor could relate to others (the platform), or to

direct experience (the train) or could “pretend” to live a special situation (the bus)... all elements that encourage interaction that goes beyond the mere push button.

Other exhibits were liked because they were surprising (the large mirage, or the ferrofluid); and others still were greatly appreciated with the support of the explainers, who could help visitors overcome an initial shyness with the more exhibits that gave the idea of lab apparatus (such as the prism setup, the electron diffraction or the photoelectric effect).

On the level of disciplinary content, as expected school groups on guided visits are the ones who “take away” the most. In this case, we have found the “follow-up” sessions to be extremely effective, because they allow students and teachers to discuss and comment what they have seen while it is still fresh in their mind, with the support of an explainer who helps them build a structured discussion.

The general visitors are given “the gist” of the physics underlying the exhibits, but to tackle the concepts presented – especially in the case of those most far removed from everyday experience – they rely on the support of the explainers to go into some detail.

The exhibition isn’t the final solution to the issue of present modern physics to the public, but it is certainly a positive experience that encourages visitors to speak and think of topics that they normally would never even consider.

So we can conclude that our games and Einstein’s thoughts have brought physics closer to those who have visited the exhibition, to experience the wonder, excitement and also the doubts lived by scientists.

References

- [1] Einstein A, 1949, Scientific autobiography in Albert Einstein: Philosopher-scientist, Vol. 7 Library of Living Philosophers (P. A Schilpp editor, Tudor, Evanston)
- [2] Quin M 1990, What is hands-on science, and where can I find it?, Physics Education 25, 243-246
- [3] Wellington J, 1990, Formal and informal learning in science: the role of the interactive science centres, Physics Education 25, 247-252
- [4] Pais A, 1983, Subtle is the Lord: The science and the life of Albert Einstein (Oxford University Press)