The *Atractor Project* in Portugal

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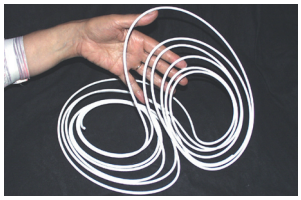
Atractor is the Portuguese word for attractor and it was the name chosen for a non-profit association created in April 1999 in Portugal for the popularisation of mathematics. Its purpose is to *attract* people to mathematics at different levels, trying to reach the broadest possible cross-section of the public. It tries to do so by giving a sense not only of the beauty and importance of the mathematical ideas and some kind of understanding of them but also of the relevance of mathematical applications in all other sciences and in everyday life. Its methodology consists of getting people actively involved by proposing physical or virtual interactive exhibits.

Translation of some extracts from the initial document [1] proposing the creation of Atractor:
«*for an important part of the population, even considered cultivated by usual standards (i.e., with an humanistic culture), it is very hard to imagine what else can be done (or discovered) in mathematics and for many people the word* mathematics *hardly means more than something related with calculations; (...) still worse, the word mathematics often has a strong negative impact related with generalised failure in school (...) and the idea that mathematics is a «finished» if not «dead» science, where all that existed to be discovered has already been discovered is not uncommon». Atractor «may help to (...) change the attitude (...) towards mathematics (...)»*

Attractors are important mathematical objects, very often with unusual and appealing shapes. They could not therefore be absent from Atractor's activities! Here are two stages in the production by Atractor (2000) of a real physical model of an orbit of a Lorenz attractor using stereolitography (the orbit begins to emerge from the powder)



and here is the final model.

The Sierpinski attractor is also present in one exhibition: each visitor throws a three colored die and a point is added to the gradually forming Sierpinski triangle.

Since Atractor's conception, an important aim has been the creation of an Interactive Mathematics Centre with a permanent exhibition and regular activities targeting schools and the general population.This centre would also be used as a privileged place for observation of attitudes concerning the proposed exhibits and activities and in a way would allow some sort of didactic experimentation. The intention is that this centre should not concentrate exclusively on itself; it should organise activities and travelling mathematical exhibitions for the whole country.

A guarantee for the national scope of its activities was given by the composition of Atractor itself; present institutional members include as founders the Association of Mathematical Teachers (APM) and the Portuguese Mathematical Society (SPM), Faculties of Science from Coimbra, Lisbon and Porto and the Universities of Aveiro and Porto. These groups were joined later by Ciência Viva (a pioneering program for developing experimental scientific activities in schools) and the Higher School for Technology of Bragança Polytechnic Institute. The Town Council of Ovar was also a founder member since the project for the intended centre was in the small town of Ovar.

Mathematics Alive

Some temporary exhibitions were organised in various towns during 1999 and 2000. The first one took place even before the legal existence of Atractor but by far the most important one was conceived, developed and built after an invitation in March 2000 from Ciência Viva and the Minister of Science and Technology to organise a temporary exhibition to commemorate the World Year for Mathematics. This Exhibition, called *Matemática Viva* [2] (Mathematics Alive) was inaugurated in November 2000 at Pavilhão do Conhecimento (Pavilion of Knowledge) in Lisbon and was due to last for 4-6 months; it was a great success and is still there six years later. Pavilhão do Conhecimento has always had exhibitions (temporary or permanent) from well known science centres in Europe and USA (Exploratorium, La Villette, Heureka, Deutsches Museum, etc) but Atractor's Matemática Viva was the first one to have been entirely conceived and built in Portugal.

Hyperbolic billiards

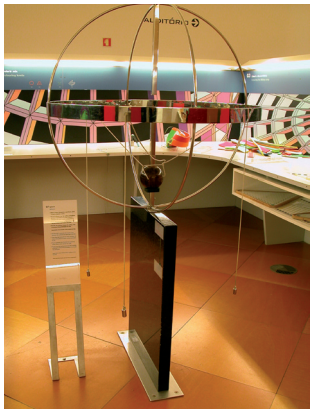
The organisation of Matemática Viva was a very hard task considering the short period, the absence of structures and the lack of previous experience of Atractor for a task of such a dimension. But it had the advantage that this was group effort by colleagues from many different institutions and this also gave increased visibility to Atractor.

The three billiard tables of *Matemática Viva* (for the three conics)

The principle of running interactive mathematical exhibitions was itself not consensual. And even for those in favour there were different possible approaches. I quote two writen statements from that time.

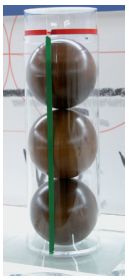
It is not evident, even for some mathematicians, that mathematics is adequate for «interactive» presentations and on the other hand some feel that such presentations may not have a scientific quality and may pervert the ideas (or the problems) they want to present.
The plan should not follow the mathematics curricula for any academic degree, although school population will certainly form a large part of the visitors. But (...) the exhibition should not be reduced to a mere tool for guided school visits.
The exhibits, although they may have an informative component, should be planned mainly to awake the visitor's active curiosity (...). Leading the visitor to voluntarily make some effort, small though it may be, to grasp an idea is certainly better than to give him/her a higher volume of encyclopaedic knowledge or mathematical results. (...) The question of scientific rigour (...) is controversial. (...) Although it is obviously necessary to avoid use of technical specialized vocabulary (...) it is crucial to avoid actually distorting the ideas to transmit under the temptation of making popularisation accessible at any cost.

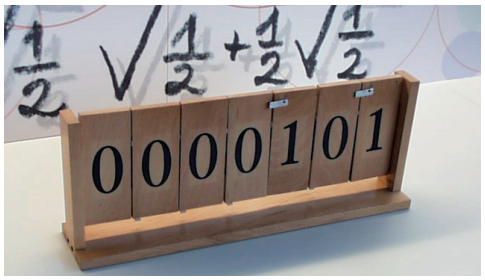
The general philosophy when designing the Matemática Viva Exhibition was to follow these general principles.



Part of Atractor's team in the real size Ames Room built for Matemática Viva; notice the relationship between size and order...
On the right the spinors exhibit.

It is not possible in this text to give an idea of the whole exhibition (50-60 different exhibits) but I shall give just a few examples. There are small non-technical exhibits like this binary mechanical counting machine and another one about pi (which is longer: the straight line or the circular one?). There are more sophisticated





exhibits like the one in which you have two musical keyboards and obtain the Lissajous curves corresponding to the frequencies of the two sounds. On the left side a table with these different curves allows you to get the ratio for the frequencies of both sounds. Close to this there is a "composer" for the (many) different tunes you can get with the well-known Mozart dice game rules.

Geometry is present in many different contexts. Two closely related exhibits are illustrated in the pictures below:

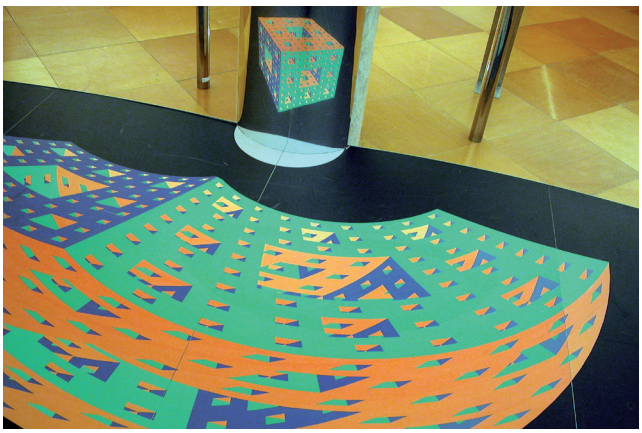
On the right a big exhibit outside the Pavilhão do Conhecimento has two rotating rods generating an invisible hyperboloid whose traces on a plane are visible hyperbolic slits through which pass the rotating rods. On the left a mechanism allows the visitor to move a handle that simultaneously deforms two families of wires to produce a variable hyperboloid with the two families of generators.

Of course many examples of experiments with soap films are available, including the Möbius band (shown in one of the pictures) and the classical *application* to solving minimal graph problems (also shown). It is striking how visitors are delighted to discover that one can get

solutions to *practical* questions (like minimising material for connecting different places with electrical cables) with analogical methods. This is the case even if they are aware that these are not examples of real applications in the sense that nobody in practice uses this method for solving these particular problems.

An imaginary *squared town* is the pretext for some problems and proposals concerning the taxi metrics...

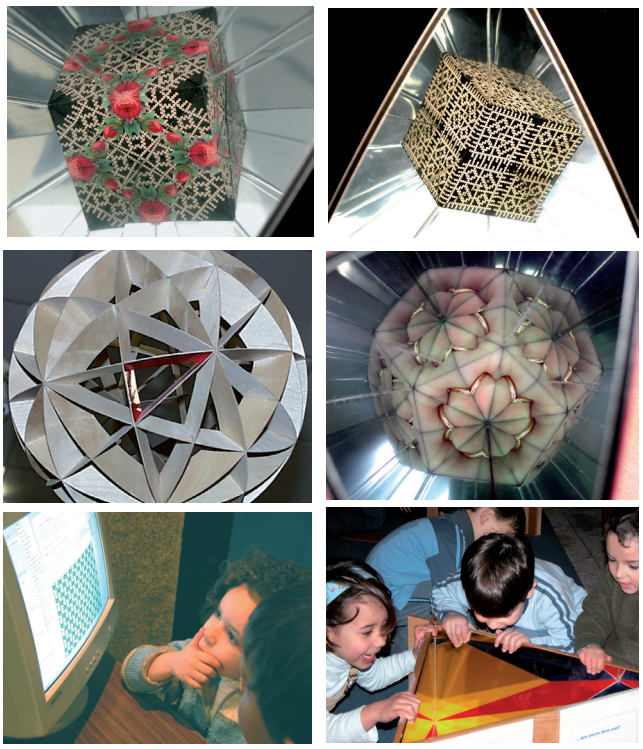
There are several anamorphoses.



A big deformed picture on the floor gives the Sierpinski cube on a cylindrical mirror around a pillar in the building.

Symmetry - playing with mirrors

Immediately after its creation (1999) Atractor participated in a joint international program financed by the European Commission, which lasted up until 2003. One important consequence of this kind of program is very often the creation or strengthening of links among participants from different countries. This has happened with Atractor and other participants and in one of the cases, i.e. the University of Milan, the collaboration lasted well after the end of the project and is still alive, now extended to the recently created inter-university structure Matematita, which includes the Department of Mathematics of the University of Milan. The collaboration with Italian colleagues led to the construction of Atractor's second important exhibition *Simetria - jogos de espelhos* [3] (Symmetry - playing



Three beautiful images from caleidoscopes with a triangular hole, a model of the fundamental regions for the dodecahedron symmetry and children attracted by symmetry.

with mirrors) a slightly enlarged version of an exhibition of a similar name at the above mentioned Italian Department. The exhibition was built in two versions: one fixed, which is intended to be included in the future Atractor's Centre and is for the moment at the University of Porto, and the other, which was organised as a travelling exhibition that has meanwhile visited more than three dozen of institutions from the extreme north of Portugal (Bragança and Viana do Castelo) to the southern Algarve. The construction of this exhibition was supported by the University of Porto, its Faculty of Science and by Ciência Viva. The fixed exhibition was inaugurated in March 2002. The support for the travelling exhibition is organised by Atractor and the training of monitors and teachers who will care locally for the exhibition in the locations visited is given at the fixed exhibition in Porto by Atractor's staff. Sometimes the visits are complemented by lectures and workshops connected to different aspects of symmetry.

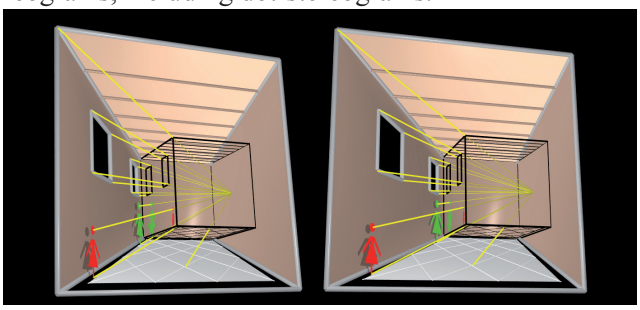
Virtual production

The construction of interactive virtual material has been used by Atractor since the beginning and not only on its site. For instance, the Matemática Viva Exhibition has an internal network of computers with some interactive material complementing the physical exhibits of the exhibition. The idea was also to have, where possible, information at different levels of difficulty, in order to allow different approaches to the same activity, according to

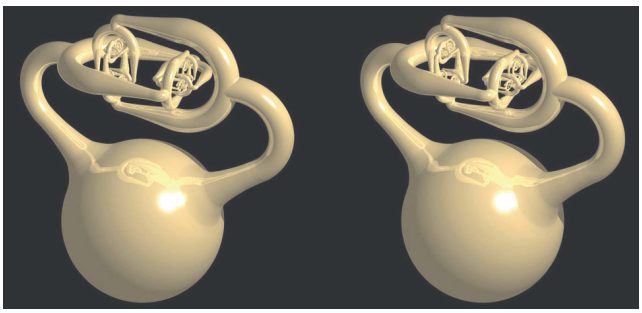
the background and age of the visitors. Given the short period of time for the preparation of the Exhibition, this program was carried out at different levels for the different exhibits. A Linux version of a program produced by the Geometry Center was implemented at the time and made freely available [4].

More recently the ability to use programs directly written in Java has given more freedom in the choice of applications to be produced. A good example is the well-known «15»-puzzle, which can be played not only on a plane as usual but also on a cylinder, a torus, a Möbius band or even on a Klein bottle. On the plane it is well-known that one can only get even permutations but what happens on the other surfaces? Does the answer depend only on the surface? You can even play with an image of your choice that you yourself send through the web [5].

One of the areas we developed in the last few years was the production of stereographic material: images, flash animations and applets. Two systems were used: one requiring two video projectors, a double graphics board, polarised filters and polarising glasses, gives very high quality for projection; the other one, present on Atractor's site [6], uses two images filling a computer display but requires a special prismatic kit developed specially by Atractor. This allows pratically everybody to see the stereo effect, which does not happen with stereograms, including dot-stereograms.

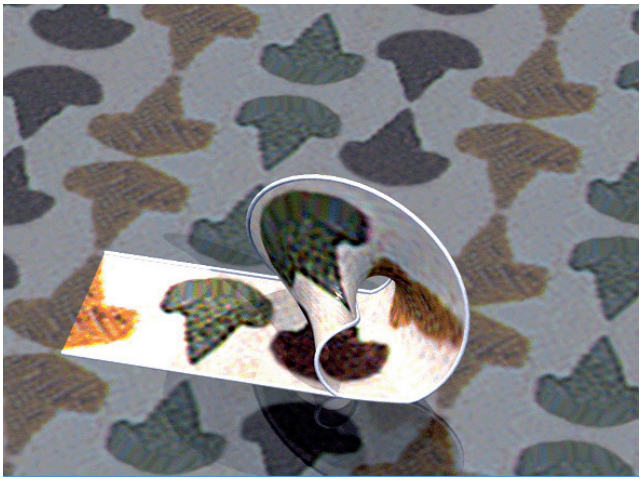


Stereogram making clear why the Ames room works



Stereogram for the Alexander horned sphere

Another very big and ambitious project is the production of an interactive DVD giving an idea of the application of Thurston's orbifolds to the study of patterns and friezes. This is in the final stages of production and will be available with text in Portuguese, English, French, Italian and Spanish. A Java interactive version (still at the revision stage) of part of the DVD can be found at [7].



The Möbius band stamping a pmg pattern (from Alhambra)

Supports

Of course all the activity mentioned above would not have been possible without continuity of the people working on the project and this required regular institutional support. This kind of support came from a variety of sources.Firstly there was the support from the Ministry of Education which assigned two secondary teachers to work full-time in Atractor from the start. Then there was the Foundation for Science and Technology (FCT), which accorded two continued grants. This was very important for the local development of competency in using specific tools for creating interactive virtual material, which allowed Atractor to start ambitious work in this area. More recently Atractor has had some grants from Gulbenkian Foundation that were crucial in complementing and giving continuity to the work already started in that area. There was also sporadic support from projects in which Atractor participated, for instance the previously mentioned project financed by the European Commission and one that is now active, called Pencil. At present there are eight young people working in Atractor (six of them full-time), all graduated in Mathematics, even those who specialised in the use of informatics tools, such as POV-Ray, LiveGraphics3D, Flash or Java. All these people with complementary competencies form a determined and enthusiastic group. Last but not least, Atractor has counted on the support of the Faculty of Science of the University of Porto, which allocated a place for this group to work in its main building over all these years.

Making a balance

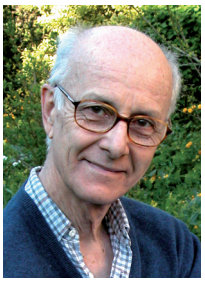
Looking back, we cannot avoid some feeling of frustration concerning one of our main goals: the creation of an interactive centre entirely devoted to mathematics and its applications. At the time of writing this text (9th April) Atractor is still waiting for a decision concerning the centre in Ovar. Excluding this (important) aspect, I would say that in all others Atractor's activity has exceeded the most optimistic initial expectations.

Concerning the future, a proposal for developing interactive material for blind children was recently approved. This idea arose from a very successful visit by blind children for activities we had specially prepared for them. We also plan to build a big interactive exhibition about topology and dynamical systems. And we have a lot of work in a final stage of production for our site and many plans for new material.

(A color PDF version of this article can be found in [8]).

References

[1] http://www.atractor.pt/geral/atrac5wp.html
[2] http://www.atractor.pt/matviva
[3] http://www.atractor.pt/simetria
[4] http://www.atractor.pt/soft/kaleido/kaleido.htm
[5] http://www.atractor.pt/mat/puzzle-15
[6] http://www.atractor.pt/geral/fr-stereoP.htm
[7] http://www.atractor.pt/mat/orbifolds
[8] http://www.atractor.pt/div/ems.pdf



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