On the 14^{th} BWMC

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Attending the *14^{th} Brainstorming Week on Membrane Computing*[1] has been a challenge in many ways. A whole week in a place I had never been before, with a group of people I did not know, and learning about a topic which existence I completely ignored. With all that, given my initial hesitation, I am glad I decided to go, because it was worth it. I attended the 14^{th} BWMC with six other Physics students from University of Barcelona who, like me, were interested in computational physics and were curious about the workshop, that took place in Seville from February 1^{st} to 5^{th}, 2016.

First of all, I could say that in some talks I got lost almost at the beginning; they were aimed for an audience with extensive knowledge on the topic of membrane computing and a solid background on mathematics and/or computer science. In other words, as a physicist and undergraduate student I felt a bit out of place. However, the tutorial sessions, that were meant to introduce membrane computing to those new to the field, were really useful and allowed me to follow the later presentations. It was also crucial and appreciated the patience of the workshop attendants; they answered any questions we asked them and even simplified some of the talks so students could follow them more easily.

Many specific topics and applications of membrane computing to other fields were presented during the talks. Some of them were more accessible for me than others, but in any way I found it interesting to listen to them, and to see how each attendee exposed about his/her research area. Despite the variety of topics that were treated, though, I would like to focus my memoir on a simple idea and a question: the basics of membrane computing, and how can it be applied to physics.

To summarise, membrane computing is a computational model inspired by nature, in which certain processes defined by rules take place in a system or cell that is hierarchically structured in compartments that are called membranes. This kind of systems, named P-systems after their creator Gheorghe Păun, are composed of multisets of objects, membranes delimiting the regions of the system, an environment, and rules that describe how a number of systems, also called machine (i.e.

[1] 14^{th} BWMC website: http://www.gcn.us.es/14bwmc.

the cell), works according to its objects and membranes, and how they interact with each other. In the simplest case, it is considered that time is the same for all membranes, so a computational step comprises a series of transitions that occur regarding to the set of rules that is applied. Furthermore, in every computational step the maximal number of possible rules is applied in each membrane. The rules will be applied in each step until no more rules can be applied, in which case the computation halts.

An interesting characteristic element of those systems is that they present the possibility of adding a probabilistic factor to the rules, so a transition can follow different rules with the corresponding probabilities that have been defined. This introduces the concept of “fuzzy logic”. Another main point of membrane computing is that it allows us to study a system with a very large number of initial objects as if all of them evolved independently and in a parallel way, like it happens on real biological systems, being the computational time proportional to the number of steps defined by the rules.

With this simple picture of the P-systems in mind, I think that it is impossible not to think in similar physical systems or in other problems that can be simplified in order to be modeled with membrane computing. In fact, motivated by the workshop attendants, which encouraged us to investigate how membrane computing could involve physics and vice versa, and moved also by our own curiosity, we thought about the improvements that membrane computing could bring into physics and in which cases could we apply it.

An important constraint we saw was that any system defined in the continuum needed to be discarded, because the set of objects that we consider is discrete. Nevertheless, membrane computing allows us to study certain magnitudes of a system with no need to define neither positions nor momenta.

The first case we decided to study was the Stern-Gerlach experiment of Quantum Mechanics. It is a simple example that can be modeled by membrane computing, where the magnitude under study is the third component of the spin of a very large number of incident particles that initially we define as positive and that after going through a Stern-Gerlach device can change or remain the same with probabilities that depend on the angle in which the Stern-Gerlach is oriented. By using a very high number of particles, the final count of positive and negative third components reproduces, respectively, the probabilities expected, and thus we show that by taking a measure, the result is altered.

The second example we considered is the uranium-238 decay chain, where we had to take several simplifications in order to apply what we had learnt from membrane computing. Initially, we start with n uranium nuclei, that naturally decay to form thorium-234 nuclei emitting α particles. While this decay takes place, since the resulting nuclei are also radioactive, they will decay in turn following the decay chain, until lead-206 is reached, which is a stable nucleus. The evident problem that this system entails is that, as we begin with n nuclei and not with a single nucleus, the number of disintegrations that compound the chain depend on the amount of parent nuclei left at every step of time, so we had to consider that a new reaction could not begin until all the parent nuclei of the step before of the chain had decayed. With that unrealistic but useful approximation, the different disintegrations or reactions that form the decay chain are uncoupled to each other, and the resulting system can be easily modeled with membrane computing. A second simplification we had to take into consideration, which derives essentially from the first one, is that the time it takes for every reaction to take place must be constant and proportional to a certain number of time steps.

With those simplifications, all complexity and part of the interest of the system vanish and we are left with a rather simple problem, so we tried to study it, as in the first case, as a statistical problem: given that some nuclei can follow different decay modes that are weighed by some probabilities experimentally determined, membrane computing allows us to count at the end of the computation, once all reactions have taken place, the amount of resultant particles of each kind that have been emitted at every step. Since our nuclei decay mainly following α and β^- decay, we expected alpha particles or antineutrinos and electrons, and therefore we could see if the amounts of the different kinds of particles (that denoted the decay mode followed in each step) were the same for every initial U-238 nuclei or showed variations. Again, this is a very simple case and with a questionable utility, but it occurred to us that perhaps it could be described with another kind of system that allowed us to remove the simplifications and consider the real system and how it evolved in time. For the time being, we are working on it.

The attendees and organizers of the venue were, as I mentioned at the beginning, another remarkable element of the workshop. They not only helped us to enter into a world of which we knew little or nothing, but also made us feel like at home and encouraged us to participate more actively in the workshop. That at the end of the workshop we were presenting the few ideas we had been able to collect during the week, apart from putting us under pressure and keeping us busy even in the sparse free hours, was also a great motivation for asking and trying to understand more deeply.

Last but not least, I would like to emphasize how much I have learnt from my colleagues. Even though most of us had not met before, we managed to work as a group, first to help each other to understand what was explained in the talks, and later to make motivation alive and to work together in our little contribution to the workshop. We had very similar motivations, and that encouraged us to naturally build a team to achieve our common goal. And, at least in my case, I have participated much more in the workshop that what I would have participated had I gone alone.

To conclude, I think it has been a very rewarding experience, useful to learn about a new topic and to see how research about it was accomplished, to practice with team work, and to motivate me to improve in my studies and to head towards research.