THE EUROPEAN SCHOOL ON MAGNETISM

Mag4Society Challenge

ESM 2020 Societal Challenges Project

January 2020

Aim: to activate [1], apply and connect the knowledge offered in the practicals and lectures.

Investment: 2 hours (before ESM). 16 hours during ESM.

Evaluation: Conference type event on last day with presentations and posters. Peer evaluated by students.

Organisation: You will work in teams of 8 participants. The teams are formed by self organisation, during match making event on the first day of the school. Each team will tackle a single problem. Each team is coached by mentor (ESM teacher). There will be 5 official coaching moments (2 hour), but coaches will be present during the school for non-scheduled advise.
We will use the 7-step method to organize the work [2]. The activities employed can range from pure literature studies, to practical implementation. The output will be a presentation and a poster, possibly supported by a report, an online blog, video etc...

Content:
For the 2020 school, we defined Societal Challenges as a topic for the project. The motivation is that we observe that governments will move away from evaluating research programs by the number of publications, and focus on the societal impact of research [3]. The question to you is how magnetism can be used to solve big societal challenges. A good starting point is the list of societal challenges formulated by the EU:

- Health, demographic change and wellbeing;
- Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the Bioeconomy;
- Secure, clean and efficient energy;
- Smart, green and integrated transport;
- Climate action, environment, resource efficiency and raw materials;
- Europe in a changing world - inclusive, innovative and reflective societies;
- Secure societies - protecting freedom and security of Europe and its citizens.

We would like to add “Curiosity” as a societal challenge as well (inspired by the success of the space exploration community).

Preparation (2 hours):
In your motivation letter, we would like you to pay some attention to the challenge that you would like to address. What possible solution do you envision? How would you interest your fellow

students to join the team? How would you organise such team, what would be your role? What output do you envision? Would you use the output after the school? Etc.
For inspiration, we have listed a number of possible project on the following pages. You are free to choose one of those, modify it, or come up with an entirely new idea.

[1] https://en.wikipedia.org/wiki/Active_learning
[2] https://en.wikipedia.org/wiki/Problem-based_learning
[3] https://www.vsnu.nl/files/documenten/Domeinen/Onderzoek/SEP2015-2021.pdf

Examples of Mag4Society projectst:

Are magnetic fields harmful?
Humanity has just recently been exposed to electromagnetic fields, only in the last two decades we started to position antennas close to our brains. We have no convincing evidence that electromagnetic waves are harmless. But did not have the chance to look at long term effects. What is the influence of magnetic fields on the well-being of people. When are magnetic fields harmful? Are pregnant women really at higher risk? Do people have a sense of the earth magnetic field, and do we confuse this capability with our fields?

Can magnetism increase the speed of computer algorithms?
We rely on computers to help us find information (search engines), detect patterns (image recognition) and predict the future (weather). Quantum computing is a way to make algorithms faster, even if computer processors does not increase in speed. Can magnetism contribute to this development, for instance by using molecular spins?

Can we still use magnetism to store data?
Our society is strongly relying on the capability to store huge amounts of data. Until now, we relied on the developments in hard disk can tape technology to store the data, both of which are magnetic. The data density on hard discs is approaching its limits, tape will in a few decades. Is it really, really true that magnetism can no longer be used to store data at relevant densities? What about cryogenic discs, atomic storage using spins?

Can we re-use permanent magnets?
To fight pollution and global warming, electric vehicles are an essential part. This means that there will be a strong increase in electromotors. There will be a considerable increase in demand for magnetic elements. Is there an economically feasible way to collect the used magnets afterwards, and generate new applications? Do we really have to melt the magnets again, and start over? Or could we re-use car electromotors in a new way, for windmills for instance? If we accidentally throw away magnets, can we easily collect them from trash?

Can we use magnetism to monitor pollution?
In the last centuries, we have exploited the environment to fuel economical progress. We cannot keep doing that, and probably even need to fix the damage we've done. An essential part is to assess the damage. Can magnetism help to monitor environmental pollution. Does the magnetism of water or soil tell us something about the quality, for instance through the presence of iron-oxide? Would such a method a cheap way to continuously monitor the environment?

Can magnetism help in green production technology?
Most of our current production technologies are very polluting and energy consuming, especially in the chemical industry. In chemistry, there are ions moving around. We know that ions are deflected by magnetic fields? Can we perhaps increase the efficiency of chemical processes by magnetic fields, so that we reduce waste products or energy consumption?

Can magnetism help to make our transportation safer?
Still people are dying from accidents with our transportation systems (cars, trains, airplanes). We managed to reduce the risk, but are still not quite there yet. One obstacle is monitoring. When there is more information on the status of our systems, we might be able to prevent accidents. Can magnetism help there? Can we for instance make magnetic distance detectors, to complement the optical systems in our car and take over in foggy conditions? Can we continuously monitor the status of our railroad system with magnetic sensors? Can we make better sensors for airplanes?

Can magnetism be used to involve the population in scientific experiments?
Whether we like it or not, science has an important role in entertaining people. Humanity has a strong need to know where we came from, and where we are going. This is how for instance space programs and particle accelerators are financed. The internet has given us the possibility not only to entertain people, but also to involve them. SETI is a good example. Can we think of research in magnetism to involve people. Could we for instance use the mobile phone magnetic sensor to map changes in the earth magnetic field? Could we find iron deposits that way? Can we predict the next reversal in the earth magnetic field?

Can we use magnetic sensors in space to warn us in time for solar winds?
Charged particles from our sun can cause severe damage to our electric and electronic infrastructure, like the 1989 breakdown of the Canadian power grid that left 130 million people without power and stopped trading at the Toronto Stock Exchange (now that is a serious societal problem!). Could we use sensitive magnetic field sensors on a satellite network in space to warn us in time?

Can we make 1 MT magnetic field, and would it be useful?
Many new technologies emerge from exploring the boundaries of our technology. We discovered super-conductivity by trying to reach the lowest temperature. We discovered radioactivity by looking for the heaviest atoms. The highest static magnetic field produced so far is 45 T. The highest pulsed field is 2.8 kT, but destroyed the magnet. What is there beyond these high magnetic fields? What is the limit? Where do we expect effects?

Can magnetism help to make our lives safer?
Military has used the distortion of the earth magnetic field to detect submarines. Perhaps that has made our lives safer, who knows? Are there other ways to use this technology. Can we detect arms or explosives from a distance, to protect our public places from terrorists? Can be protect our pedestrian crossings? Can we detect the occasional moose on the highway?

Can we use magnetism to desalinate water?
Shortage of water is a serious problem in many parts of the world. In principle we have oceans of water at our disposition. But the salt in the water makes it lethal. We can desalinate at the cost of massive energy consumption. Since during desalination, ions move out of the water, perhaps we can make the process more efficient with a magnetic field?

Can we use magnetism to check our food?
Still many people die from food poisoning, also in our modern societies. Especially the older and sick are at risk. Our current solution is to put an expiration date on the package and throw it away when the data has passed. To be safe however, the expiration dates are far too short. This leads to enormous spillage. Could we use magnetism to detect whether food is still good to eat?

Does it make sense to use superconducting magnets in wind turbines?

Wind turbine parks are now at their break-even point: the cost less than they produce over a lifetime. The main reason is that they get bigger. It might therefore become economically feasible to use superconducting electromagnets, rather than permanent magnets in their generators?

Can magnetic nanoparticle be used to fight malaria?
Malaria can be easily avoided or cured, but still many people die of a malaria infection. The reasons are political, most malaria casulties are in unstable regions. It would be really nice however if we can exterminate malaria without having to actually bring people into these regions. Can we use magnetism to do that?

Can we eat magnets?
There is a lot one can do with magnets in health care. A really nice idea is to swallow components, that self-assemble magnetically in the stomach into a surgical robot. But how to get it out again? What if you could simply digest it?

Can we make environmentally friendly magnets?
It is not a good idea to throw you permanent magnets into the environment. Neodymium might be toxic for instance. But iron-oxide is not bad for the environment at all. Could we make permanent magnets that are perfectly safe to leave behind in nature?

Can we use magnetocalorics to make a small volume fridge?
Our fridges are currently our most energy hungry devices in our homes. Even if you are not at home, they are wasting away energy. Some fridges are really full. Other however, are near empty. In any case, we always cool our fridges for the most sensitive product. It might be really useful if we can store our food in cooled boxes in the cupboard, rather than in a big fridge. We can adjust the temperature of each box to match the need of its contents. Boxes that are not filled, are not cooled. Wouldn't that safe a lot of energy? Our current technology is ancient, using evaporation for cooling. There has been tremendous progress in using the magnetisation cycle for cooling. Could we make smaller fridges that way? Could we make cooling boxes in which your a single package of milk, a steak, an egg?

Magnetic challenge