THE EUROPEAN SCHOOL ON MAGNETISM

September 11 to 23, 2022

Magnets for Sustainable Development

ESM 2022 Basic Science for Sustainable Development Project

Version 1, February 2022

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

Investment: 2 hours (before ESM). 20 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 a 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 4 official coaching moments (2 hour each), 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:
Since 2022 is the UN year of Basic Science for Sustainable Development [3,4], we took this a topic for the project. Of course our science is magnetism. The question to you is how magnetism can be used to create a more sustainable world. Some examples of areas where magnetism can help:

- **Health care and well-being**:
  Cost reduction, early diagnosis, minimally invasive surgery, etc
- **Mobility**:
  Smart, green and integrated transport: zero carbon emission, circular economy, resource efficiency and raw materials, etc
- **Energy production**:
  Secure, clean and efficient energy: zero carbon emission, quality of service, etc
- **Energy consumption**:
  Energy consumption of internet, industry, homes, etc
- **Agriculture and forestry**:
  Water management, bio-economy, environmental pollution, etc

Preparation (2 hours):
In your motivation letter, we would like you to pay some attention to the problem 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.iybssd2022.org/
[4] https://council.science/current/press/international-year-of-basic-sciences-proclaimed-un/

Examples of Sustainable Development projects:

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 magnetism help to reduce the energy consumption of the internet?
The energy consumption of our internet infrastructure is exponentially growing: communication, data-base searches, crypto-currency. Can magneto-electronic devices help to reduce the energy, for instance by energy efficient algorithms and quantum computing?

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 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 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. Could we use sensitive magnetic field sensors on a satellite network in space to warn us in time?

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 nanoparticles 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 casualties 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 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 magneto-calorics to make an energy efficient 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?

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 still use magnetism to reduce energy to store data?
Our society is strongly relying on the capability to store huge amounts of data, for instance in magnetic hard discs and tapes. In principle, we need about 60 kT of energy to store one bit of information for years. Current system are far worse (how much?). Can we improve that?

Zero carbon emission mobility