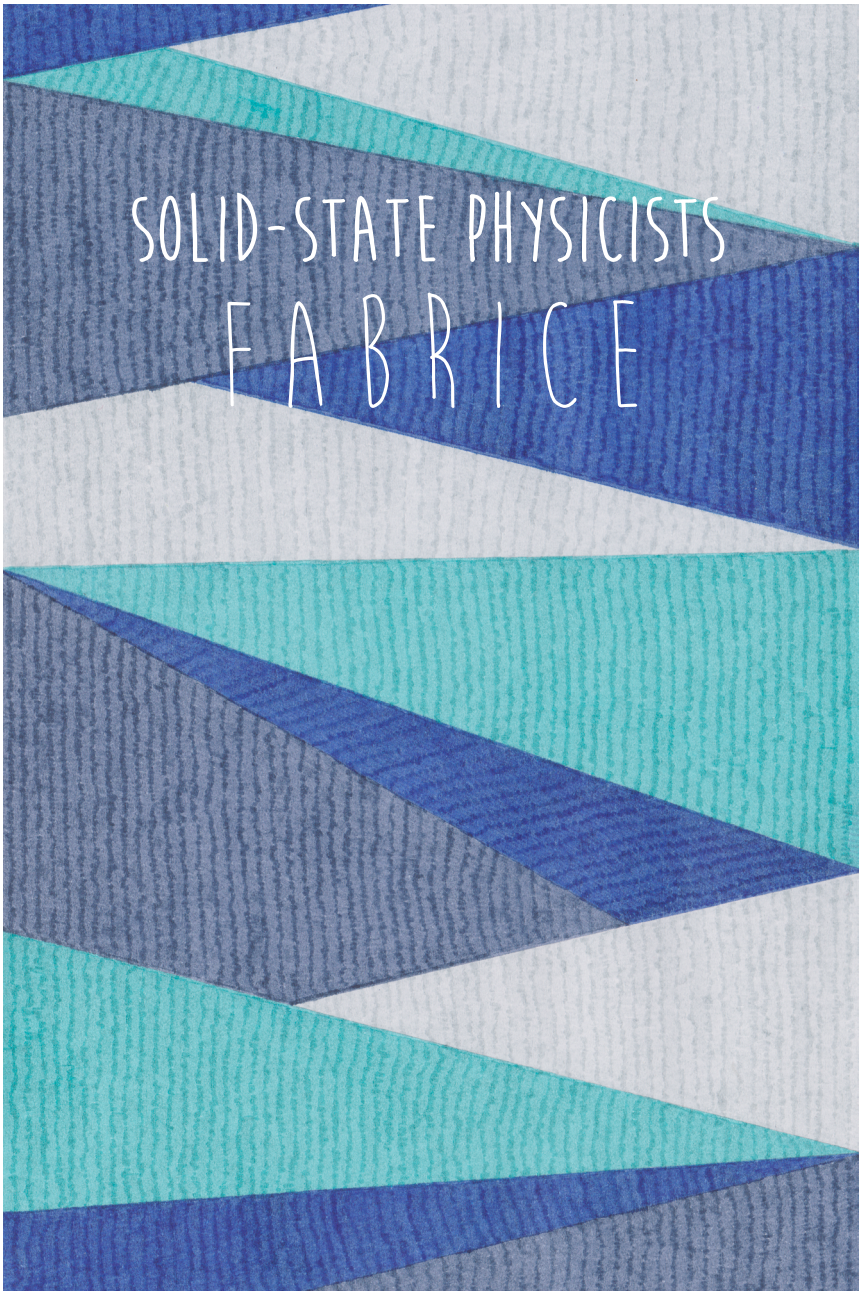
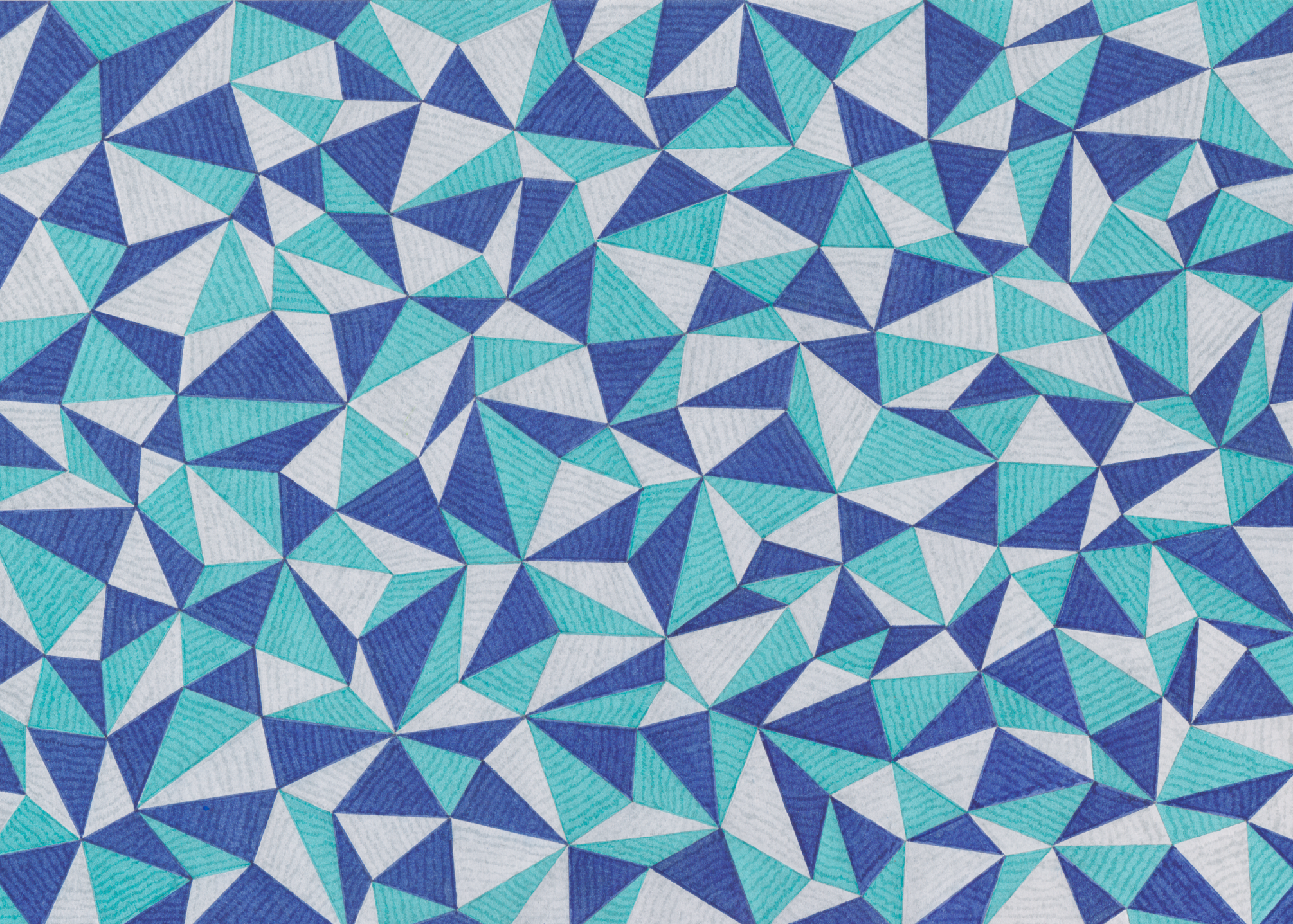
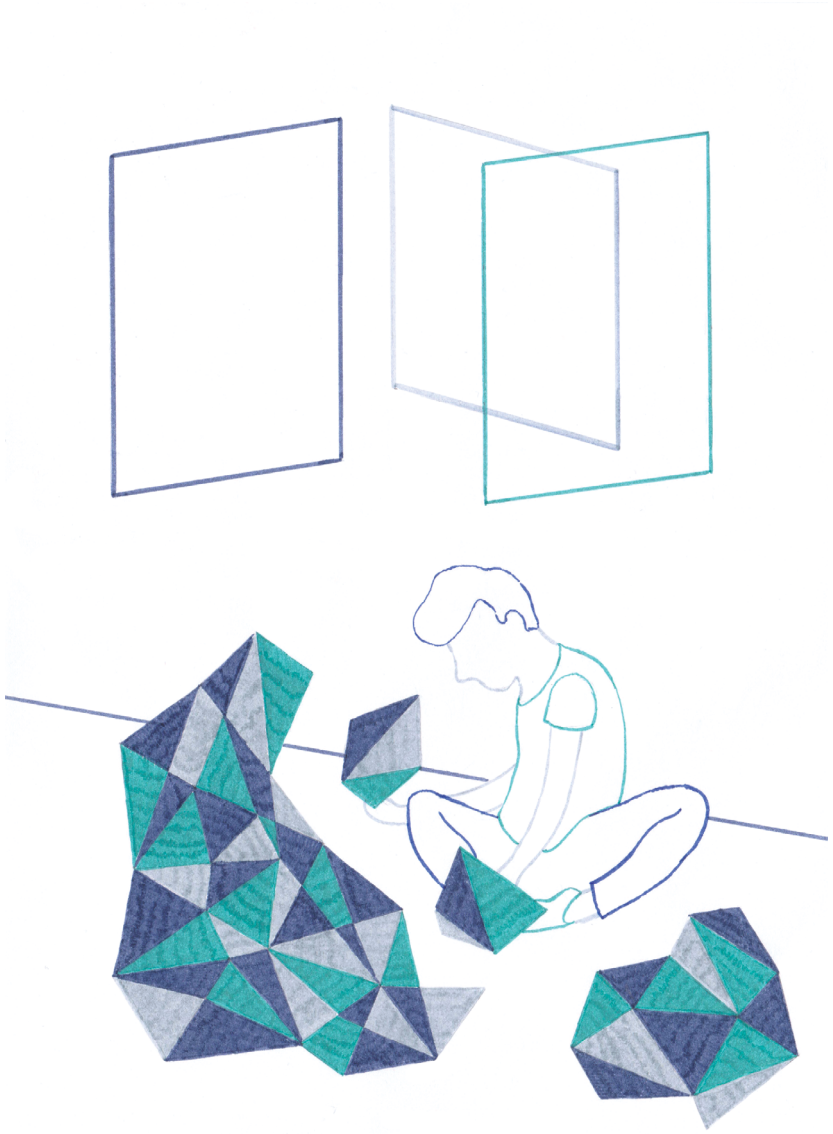

SOLID-STATE PHYSICISTS
FABRICE



SOLID-STATE PHYSICISTS

FABRICE

PHYSICS PROFESSOR, RESEARCHER EXPERIMENTER
AT THE LABORATORY OF SOLID-STATE PHYSICS (LPS)
TEAM : NEW ELECTRONIC STATES OF MATTER
41 YEARS OLD
WORKS ON QUANTUM MAGNETISM

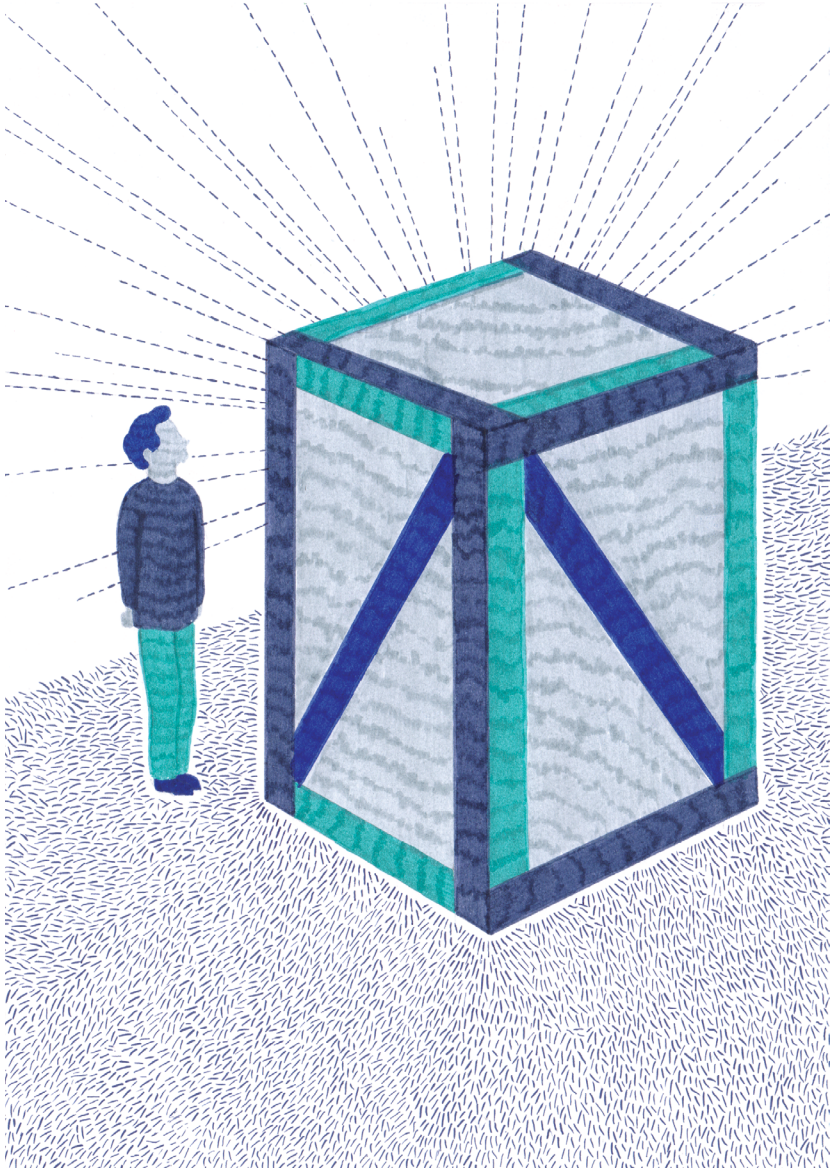


When I was a kid, I never thought: "I'm gonna be a researcher" that's for sure; but I always liked the idea of being an engineer.

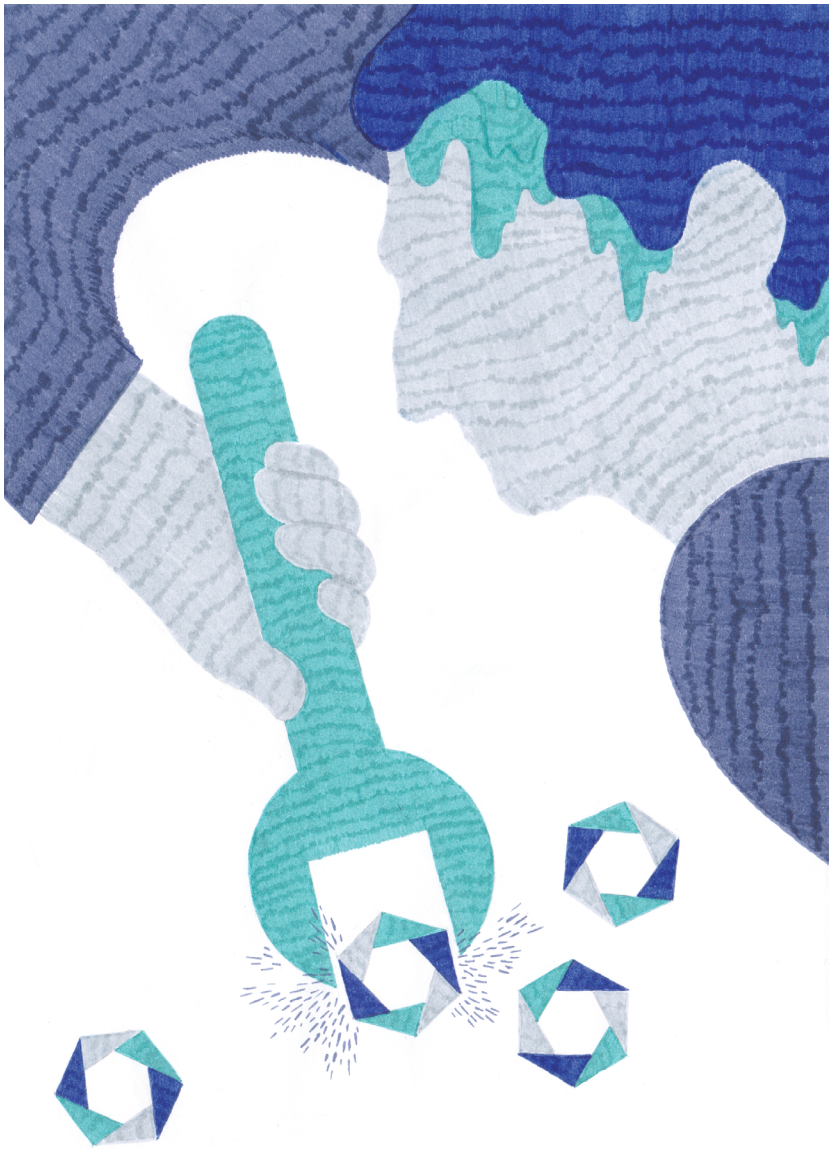
Of course I didn't even know at the time what an engineer was. But I really liked drawing little machines, seeing how things worked.

THE FIRST TIME I CAME TO THE LAB, IT WAS FOGGY AND I ENDED UP IN THE MIDDLE OF NOWHERE. I REMEMBER THINKING TO MYSELF : "WHERE AM I? ON THE MOON?" AT THE TIME, I LIVED IN PARIS. TO ME, ORSAY WAS AT THE END OF THE WORLD ! AND TEN YEARS AGO, IT REALLY WAS THE END OF THE WORLD ! WE WERE SURROUNDED BY CORNFIELDS.

IN SOLID-STATE PHYSICS, I LIKED THE IDEA OF DEALING WITH REAL MATERIALS. UNDERSTANDING MATERIALS THAT DON'T NEED YOU TO EXIST.



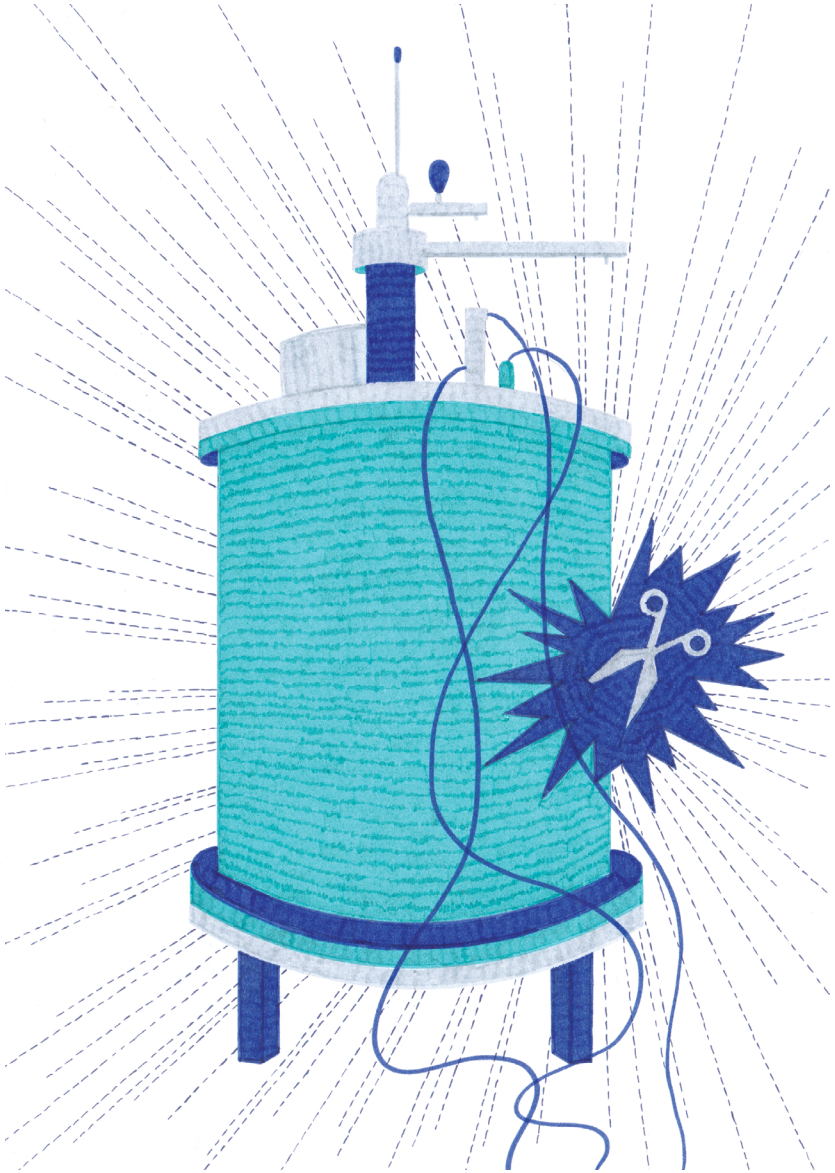
AND THERE ARE SOME GREAT MOMENTS, LIKE WHEN YOU RECEIVE A NEW EXPERIMENTAL SETUP.



INSTALLING A NEW SETUP IS HARD WORK, LIKE REALLY HARD WORK. SOMETIMES YOU EVEN NEED A CRANE TO LIFT SOME OF THE HEAVY DEVICES.

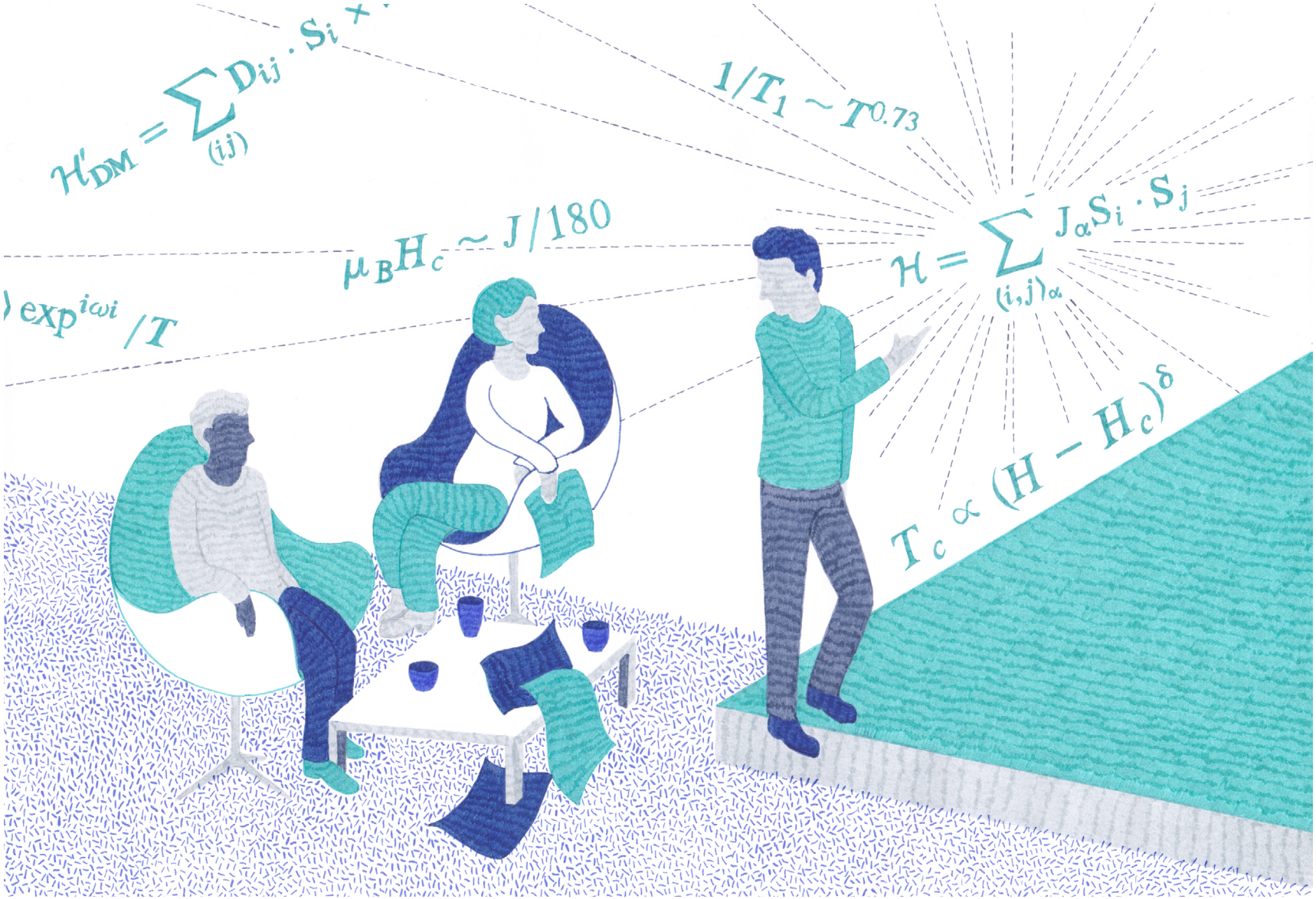
THE FIRST TIME YOU TURN EVERYTHING ON AND IT ACTUALLY WORKS, IT'S SPECTACULAR.

THE FIRST TIME WE GOT AN NMR SIGNAL, WE PRINTED THE SPECTRUM AND DISPLAYED IT IN THE LAB.



Recently, we ruined a really old experimental setup. A PhD student let a pair of scissors get inside the main magnet... and it broke everything.

The whole system had been kept at the right temperature for twenty-five years, and we lost the magnetic field in an hour. Still, it was pretty funny, because we expected it to happen, one day, but certainly not because of a pair of scissors!



WHEN WE HAVE A MEETING TO DISCUSS DATA, IT KEEPS GOING BACK AND FORTH, UNTIL AT ONE POINT, YOU REALIZE : "YES, I THINK WE ARE ONTO SOMETHING." AND IT'S ALWAYS LIKE THAT : WHATEVER THE TOPIC, THERE IS ALWAYS THIS MOMENT WHEN IT CLICKS. IT DOESN'T MEAN YOU'VE UNDERSTOOD EVERYTHING, IT'S MORE LIKE THE FOG STARTS TO DISSIPATE AND YOU BEGIN TO SEE THINGS CLEARLY.

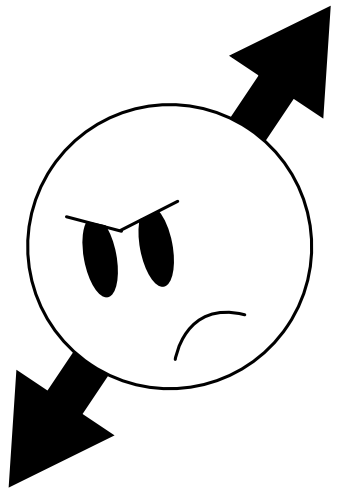
AS AN EXPERIMENTER, IT'S ALWAYS INTERESTING TO COMPARE OUR WORK TO THE WORK OF THEORETICIANS, BUT IT'S NOT ALWAYS EASY BECAUSE WE DON'T REALLY SPEAK THE SAME LANGUAGE. THAT SITUATION IS DUE TO THE FACT THAT MOST OF THE TIME, EXPERIMENTAL LABS AND THEORETICAL LABS ARE SEPARATED.

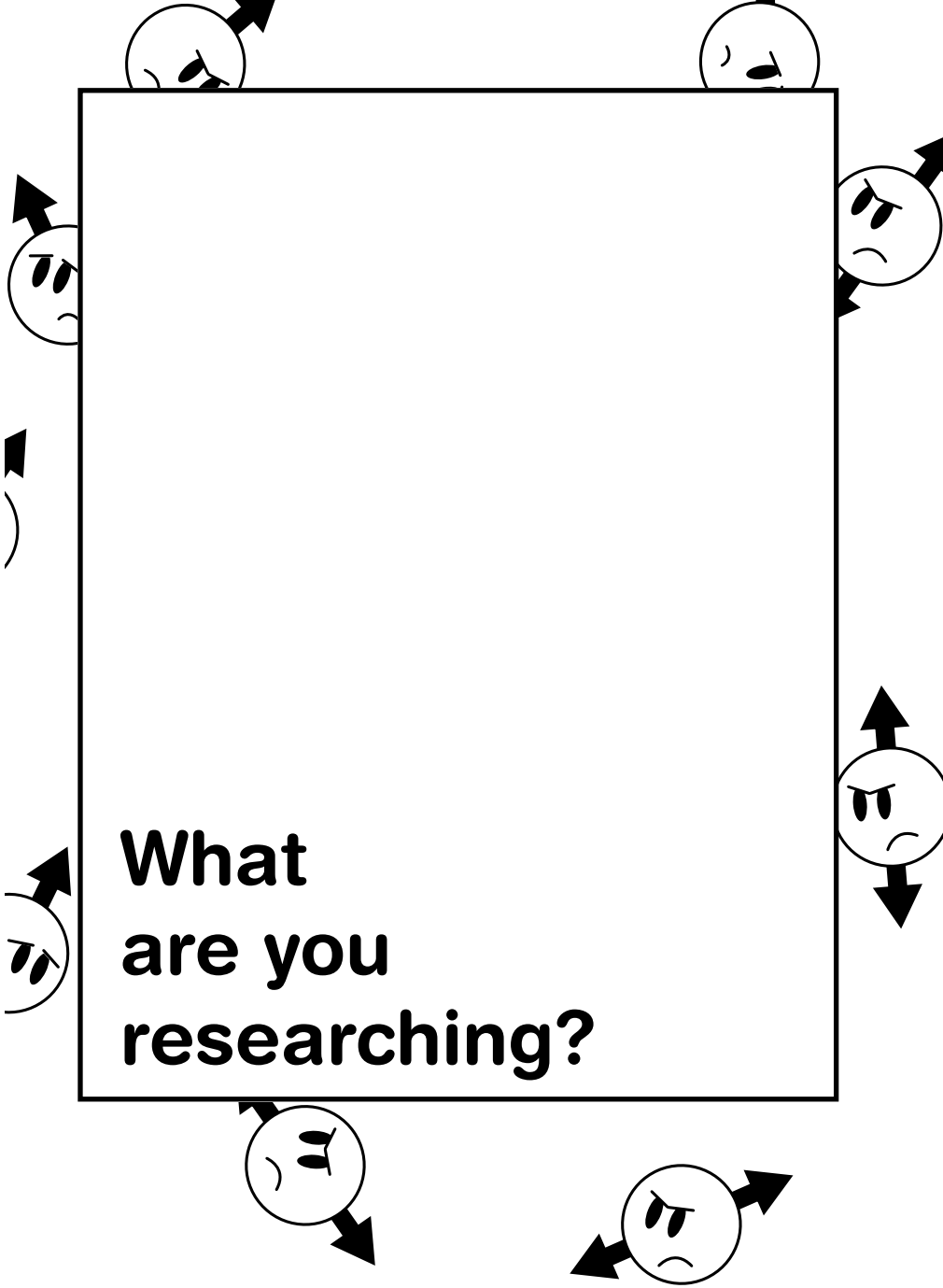
Being a teacher/researcher can be a bit schizophrenic. One day, you're in your lab experimenting, the next, you're in front of a class full of students. It requires different skills. It's really not the same job. It's like a phase transition : when you work as a researcher, you can feel lonely in your lab ; whereas when you teach, you open up, you have to communicate. That's the nice part.

WE OFTEN HAVE TO TRAVEL, TO ATTEND CONFERENCES OR BECAUSE OUR EXPERIMENTS REQUIRE IT. ONE OF THE SCIENTIFIC TRIPS I REMEMBER MOST CLEARLY WAS IN GRENOBLE (NOT THE MOST EXOTIC CITY IN THE WORLD), TO WORK ON NMR SPECTROSCOPY WITH HIGH PERFORMANCE MACHINES. THE RHYTHM WAS VERY INTENSE. USUALLY, WITH MUSR, WE HAVE 3 TO 4 DAYS, WHICH IS SHORT, BUT IF IT DOESN'T WORK, WE STILL HAVE TIME TO WORK IT OUT. THAT TIME, WE ONLY HAD 6 HOURS, IN THE MIDDLE OF THE NIGHT. YOU CAN IMAGINE HOW STRESSFUL THAT WAS. ANYWAY, WE HAD A GREAT TIME.

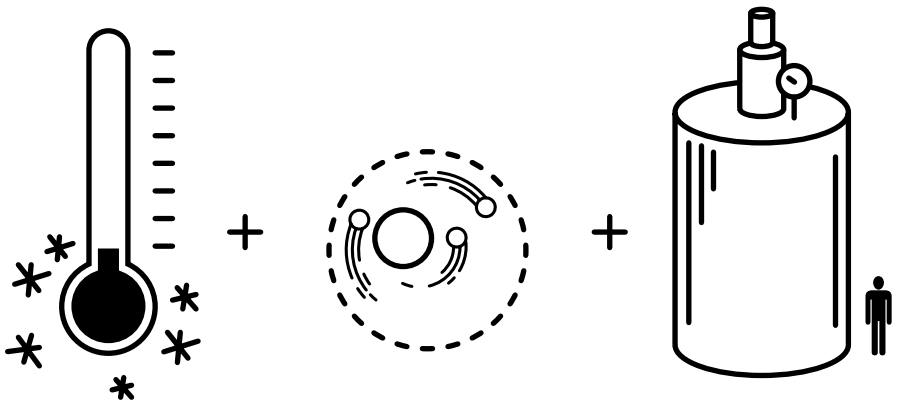
MY KIDS ARE 5 AND 8, THE AGE WHEN YOU'RE THE MOST CURIOUS ABOUT EVERYTHING. I'M EAGER TO SEE IF THEY'LL CHOOSE A SCIENTIFIC CAREER. THEY REALLY LIKE THE LAB, THEY FIND IT FUN. I GUESS IT MAKES THEM FANTASIZE.

WE MAKE STUFF LEVITATE, THERE'S ALWAYS HELIUM TO PLAY WITH, AND AT THE END OF THE DAY, THEY GO HOME WITH A BALLOON... SO I GUESS WE ARE TRYING TO TURN THEM INTO SCIENTISTS! ANYWAY, IT CAN'T BE BAD FOR THEM!

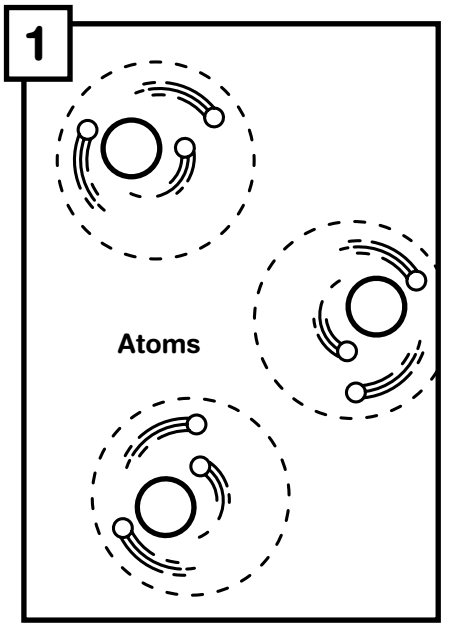


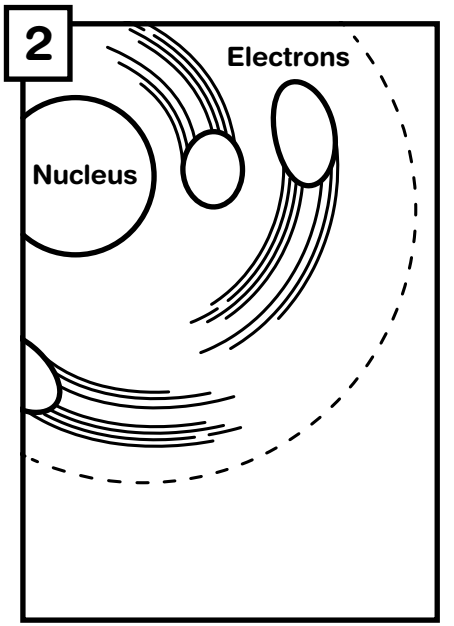

What
are you
researching?

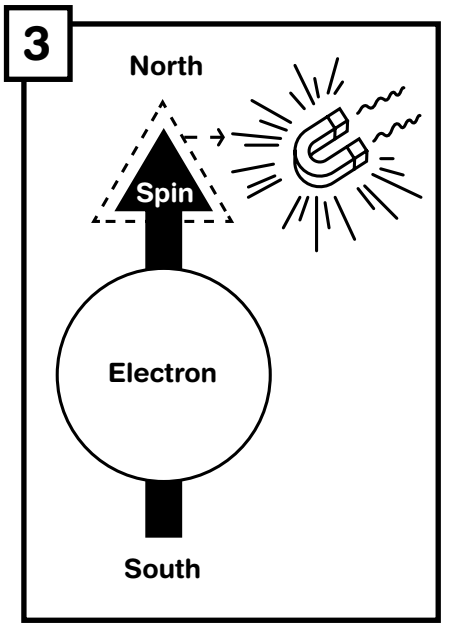
At really low temperatures, certain magnetic materials cannot stabilize and become “orderly.” They behave like some sort of magnetic fluid and are called “quantum spin liquids.” How and why? Those are the questions Fabrice is trying to answer.



Cold + Electrons + Big machines







The spin

1 — Matter is made of atoms.

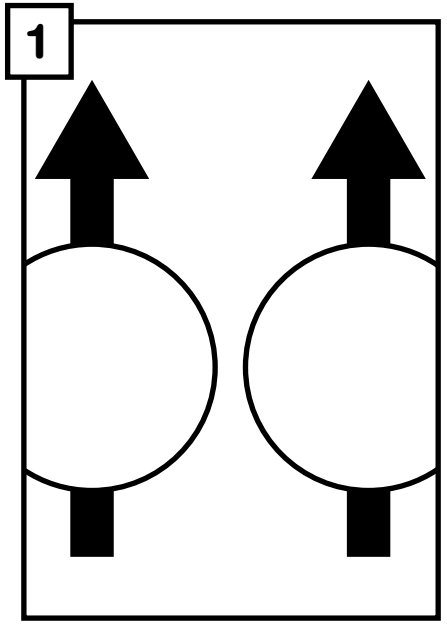
2 — Each atom contains electrons.

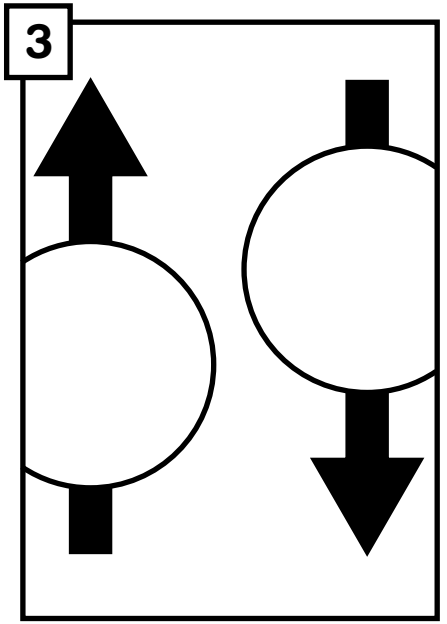
3 — Each electron carries a “spin,” which is a tiny magnet. That magnet has a north pole and a south pole, but it obeys the laws of quantum physics.

The different types of order

1 — In matter, spins can interact.

2 — Sometimes, all the spins want to align: the material becomes a magnet.

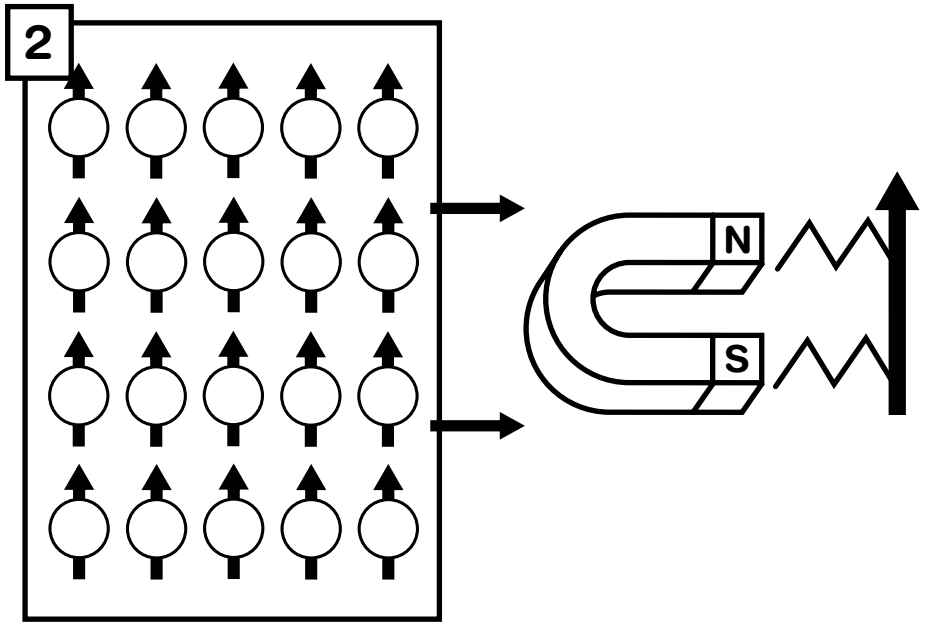


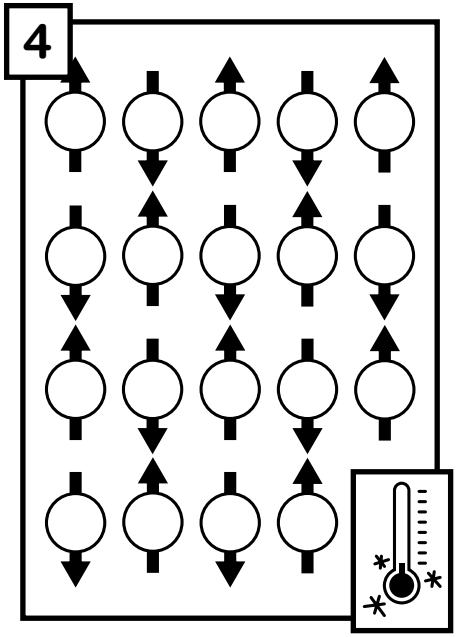


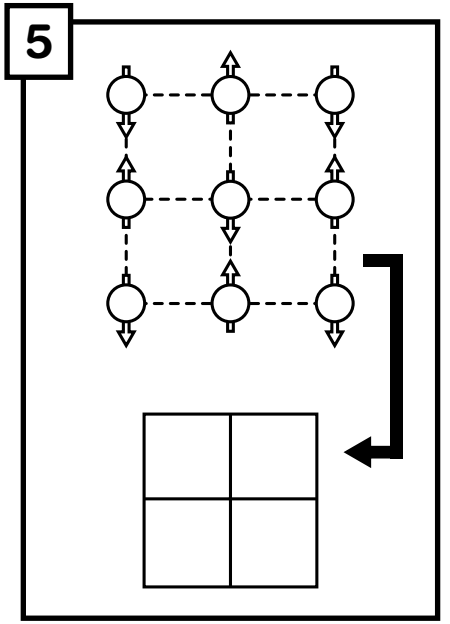
3 — Sometimes, the spins want to break the alignment.

4 — At really low temperature, a material based on these spins becomes “orderly,” but this time, all the spins are head to toe. The material is called “antiferromagnetic.”

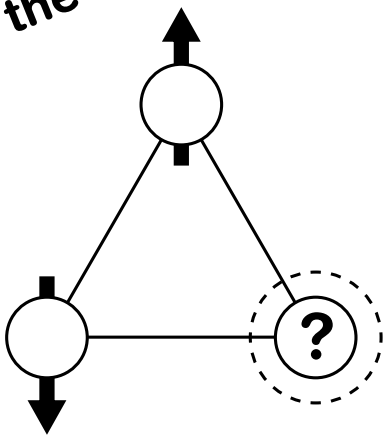
5 — The spins can all be head to toe because they are arranged in a square.







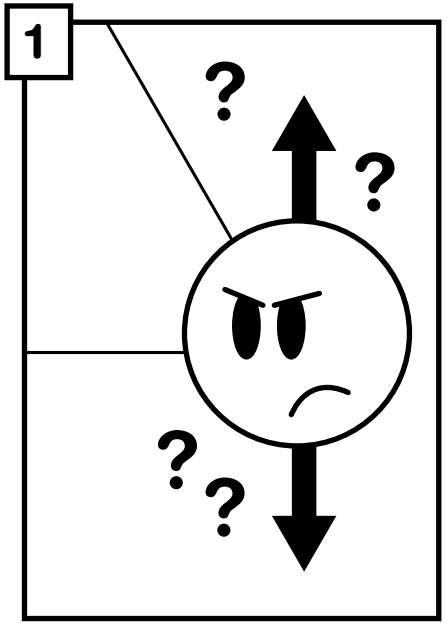
Frustrating the spins

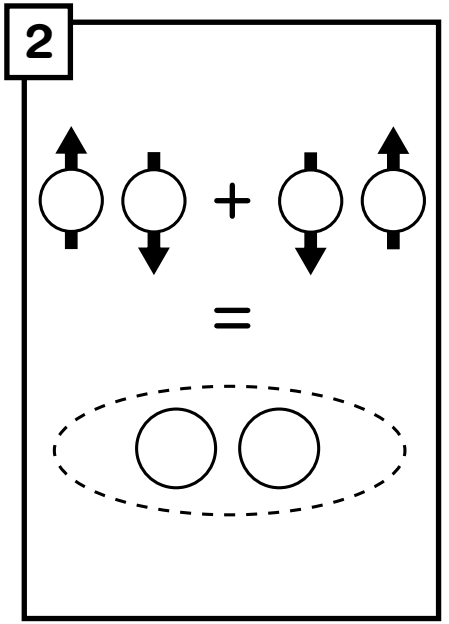


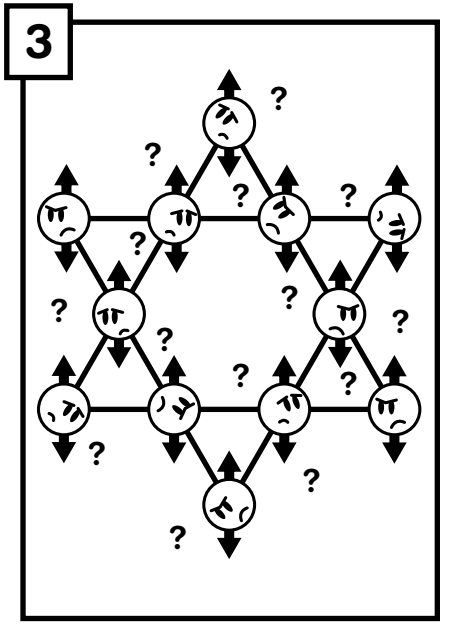
If spins are put on a triangle rather than a square, they cannot be head to toe.

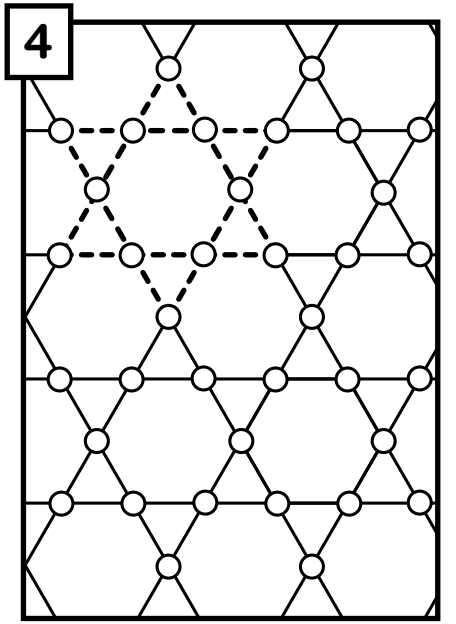
1 — We say that the spins are frustrated.

2 — Thanks to quantum physics, two spins of neighboring atoms can adopt some really strange behavior. For example, they can, in a sense, put themselves in both combinations of head to toe simultaneously. When this happens, they must be represented differently.





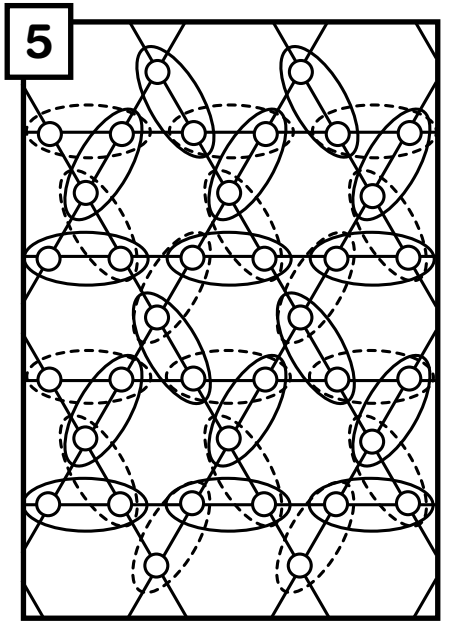


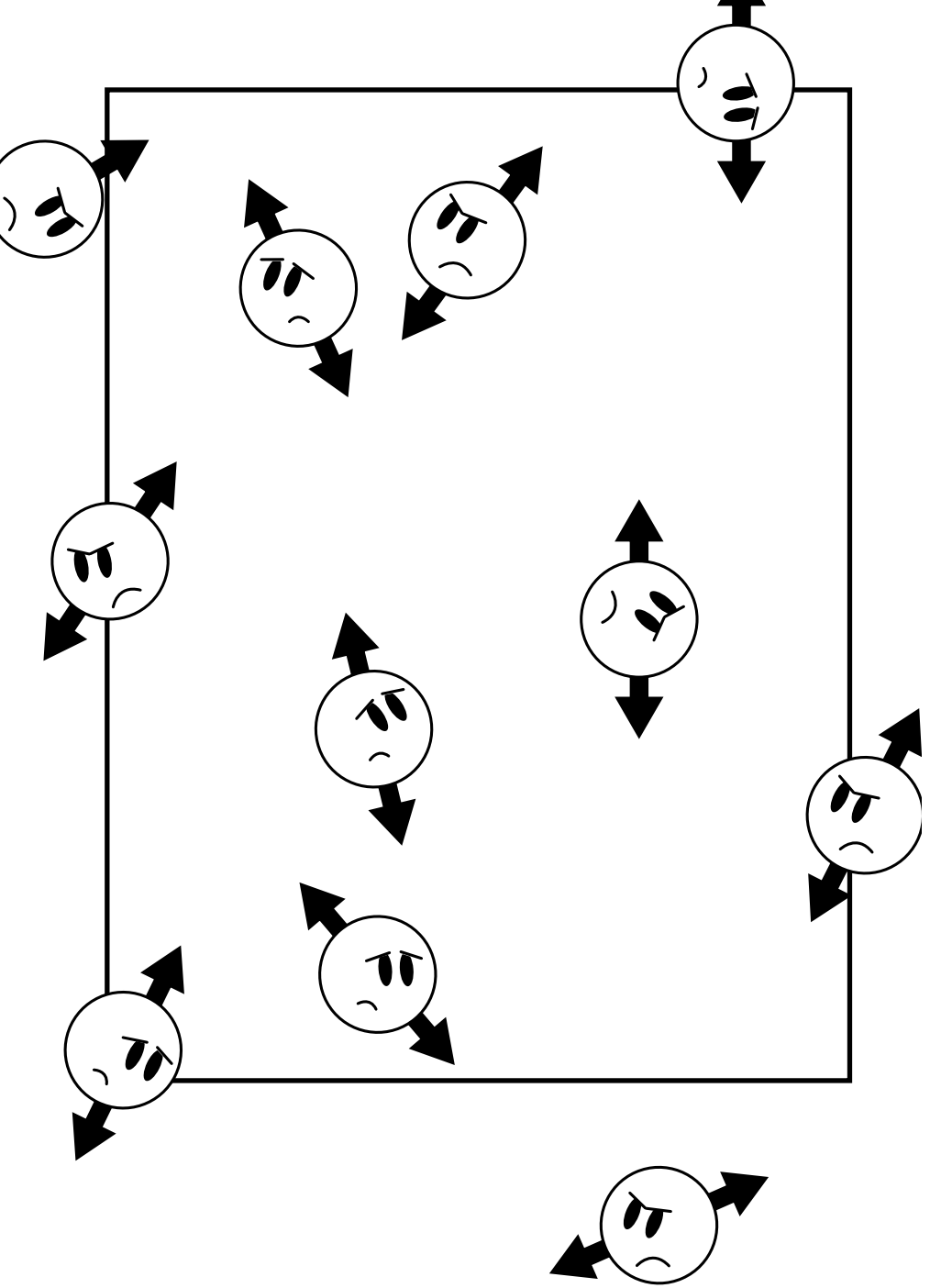


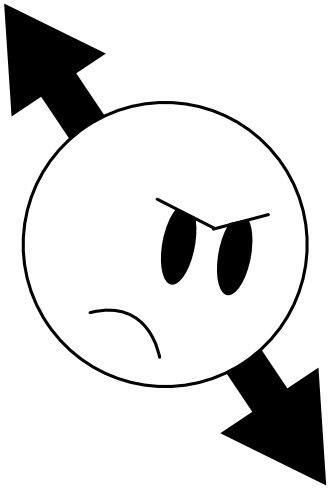
3 — Similarly, if the atoms form a Star of David, the spins are also frustrated.

4 — Fabrice makes measurements on materials called “Kagome,” which consist of several Stars of David put together. On this network, the spins refuse to become orderly and they remain dynamic. This state is called “quantum spin liquid.”

5 — Fabrice’s measurements seem to prove that the spins enter different quantum states at once, even close to absolute zero! The only question that remains is how…







A CREATION BY CHLOÉ PASSAVANT,
AS PART OF HER DSAA SCIENTIFIC ILLUSTRATION DESIGN DEGREE,
WITH THE COOPERATION OF JULIEN BOBROFF (UNIVERSITÉ PARIS-SUD, CNRS)
THIS WORK WAS CONDUCTED AT THE LABORATORY OF SOLID-STATE PHYSICS (LPS)
IN ORSAY, WITH FABRICE BERT, LORÈNE CHAMPIGNY, MARK-OLIVER GOERBIG.
I WOULD LIKE TO THANK THEM FOR TAKING PART IN THAT PROJECT.
TRANSLATION : PIERRE SZCZECINER
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