Magnetic Molecules – are tomorrows bits synthetic?

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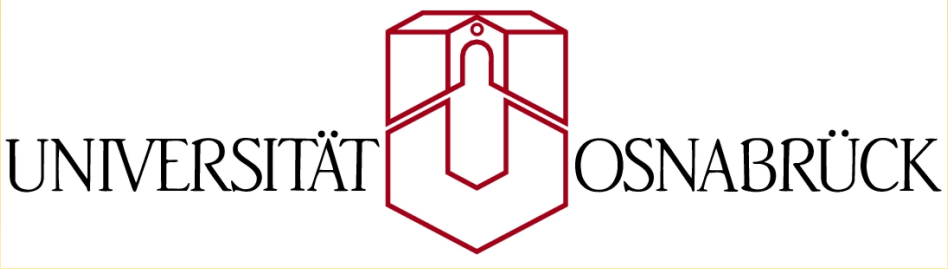

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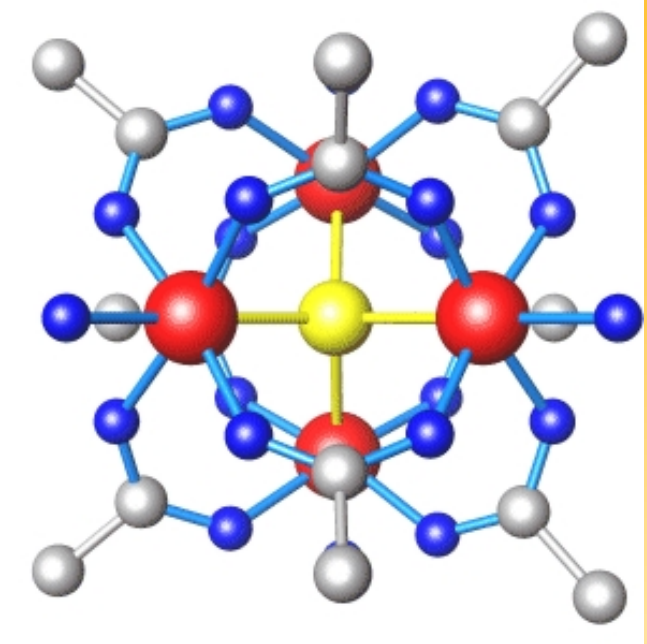
Contents

VDI-Technology Prognosis Molecular Magnets

- **1987** first ferromagnetism in an metal-organic substance ($T_c < 4.8$ K);
- **1989** discovery of the LIESST effect (Light-Induced Excited Spin State Trapping) with spin crossover substances;
- **1990** first ferromagnetism in a pure organic substance ($T_c < 1$ K, today $T_c < 35.5$ K);
- **1991** ferromagnetism in an metal-organic substance ($T_c > 350$ K);
- **1996** discovery of macroscopic magnetisation tunneling in a single crystal of metal-organic nanomagnets.

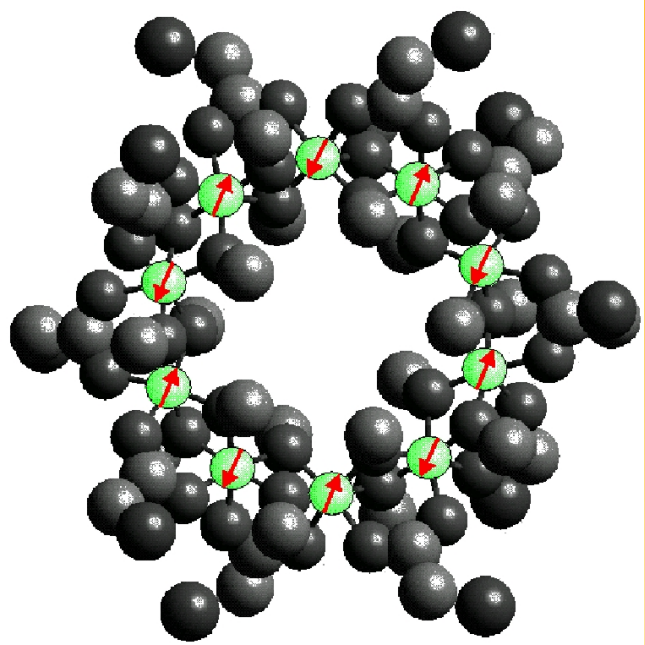
http://www.vdi.de/vdi/organisation/schnellauswahl/techno/arbeitsgebiete/zukunft/sub/02194/index.php

What are magnetic molecules?



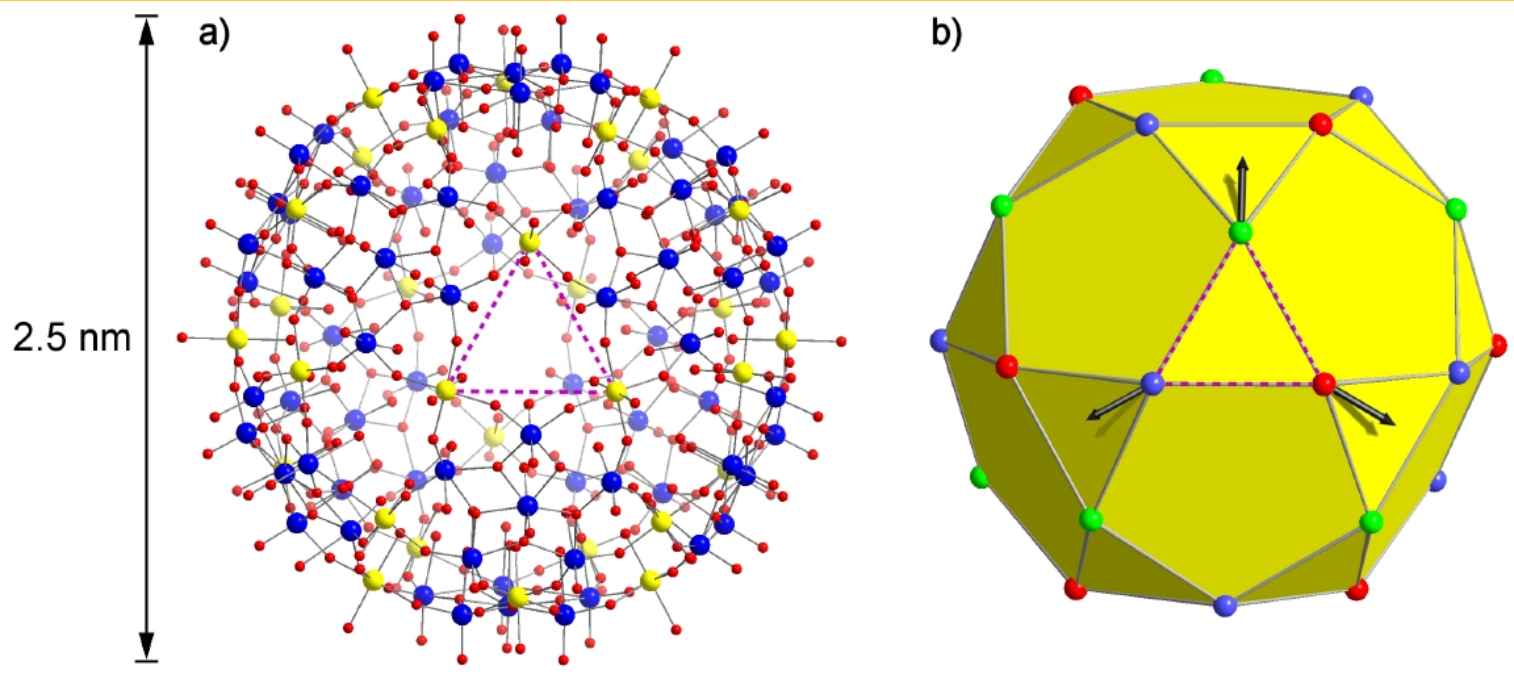
- macro molecules, e.g. polyoxometalates: consist of constituents like Hydrogen (H), Carbon (C) and Oxygen (O) as well as paramagnetic ions like Iron (Fe), Chromium (Cr), Copper (Cu), Nickel (Ni) or Manganese (Mn);
- pure organic magnetic molecules: magnetic coupling between high spin molecules (e.g. free radicals);
- intermolecular interaction relatively small.

Structure of magnetic molecules

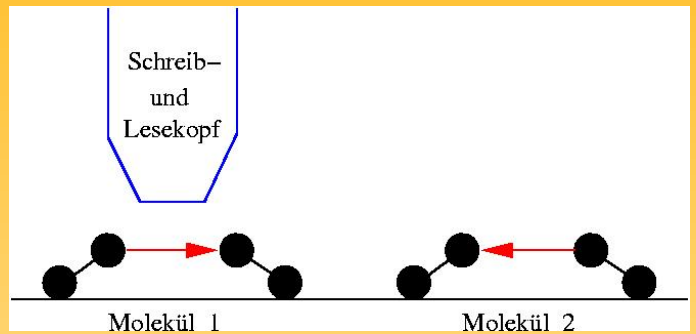


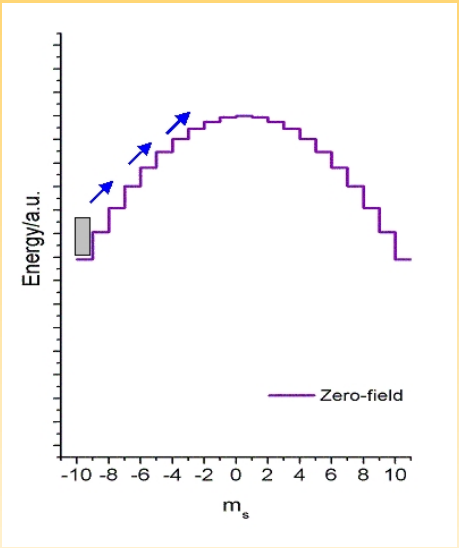
- dimers (Fe_2), tetrahedra (Cr_4), cubes (Cr_8);
- rings, especially iron rings (Fe_6, Fe_8, Fe_{10}, ...);
- complex structures (Mn_{12});
- soccer balls, more precisely icosidodecahedra (Fe_{30}) and other macro molecules.

Example for magnetic makro molecules $\{Mo_{72}Fe_{30}\}$



Magnetic molecules as storage media?

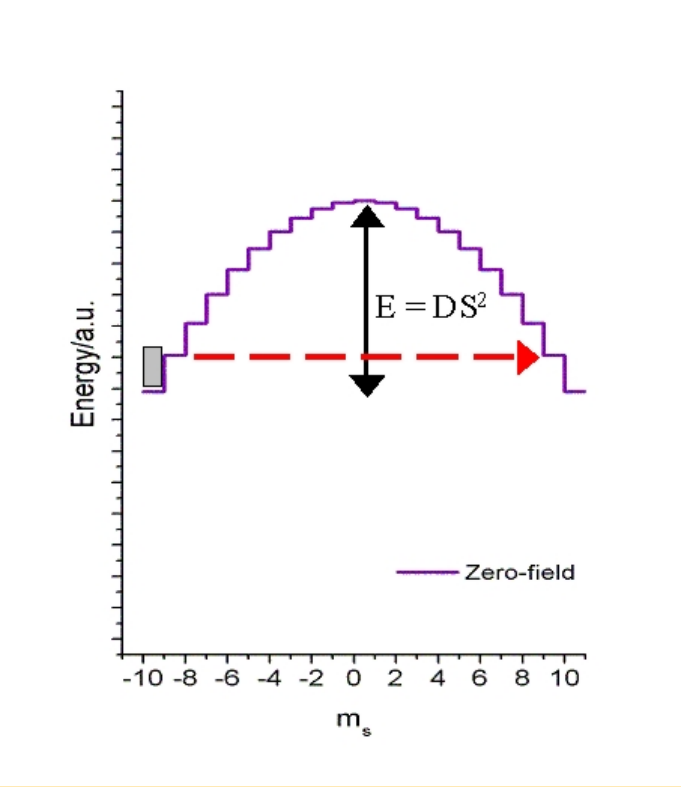




Advantages:

- every molecules is a domain of its own; very weak intermolecular interactions; high density and nevertheless good separation of magnetic moments;
- high spin possible, e.g. $S = 10$;
- magnetic molecules show hysteresis;
- theoretically possible storage density:
  40 Tbits per square inch,
  today: 20 Gbits per square inch (IBM), 300GB per square inch (Fujitsu 05/2002)

Magnetic molecules as storage media?

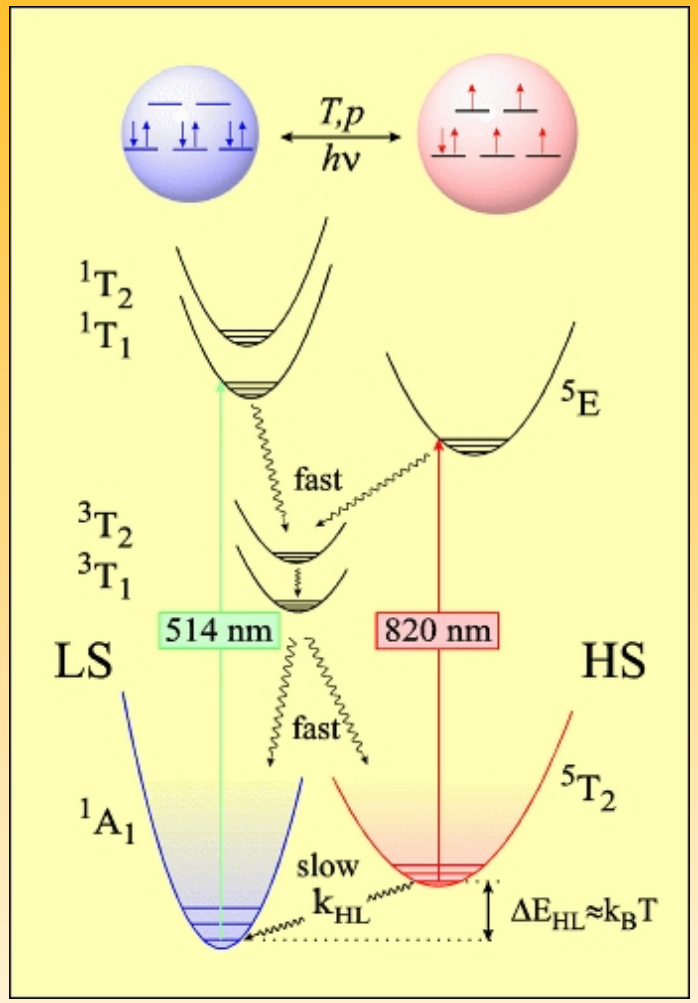


Disadvantages:

- magnetisation tunneling! stabilisation by appropriate substrate?
  (Prof. Blügel, Osnabrück/Jülich, http://www.flapw.de)
- often very small coupling ($J \approx 10$ K), i.e. thermally unstable at room temperature;
- recording head must be very small and needs precise guide.

http://www.people.man.ac.uk/~mbdssrew/winpeny_intro3.html

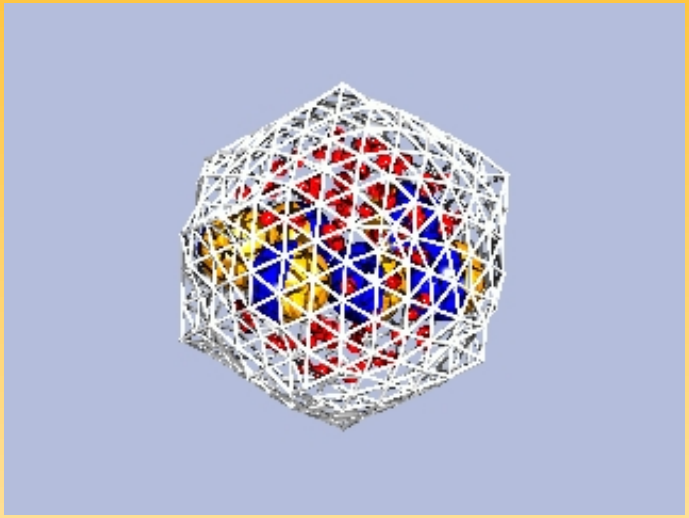
Light Induced Excited Spin State Trapping (LIESST)



- magnetic molecules may serve as optical switches or displays;
- materials: spin crossover substances which show the LIESST effect;
- principle: reversible change in colour when irradiated with laser light or when heated as well as cooled.

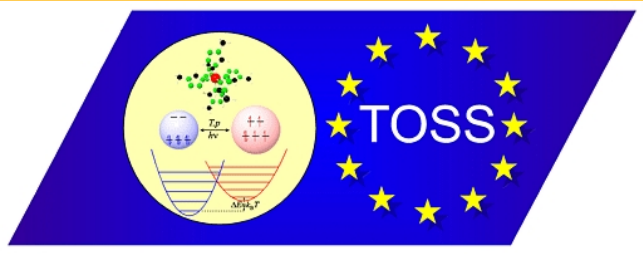
http://ak-guetlich.chemie.uni-mainz.de/toss/liesst.shtml

Further applications of magnetic molecules



- magnetic molecules may act in biological systems, e.g. as transport media, collecting device or for precise drug deposition
  (patent Dr. Peter Borrmann);
- magnetic molecules may be used as contrast material in resonance tomography;
- magnetic molecules may be useful as catalysts or in quantum computers.

Research funding for magnetic molecules



- **EU:** Thermal and Optical Switching of Molecular Spin States (TOSS);
- **DFG:** Key program 1137: Molecular Magnetism;
- **DOE:** z.B. Ames-Lab, Iowa, USA;
- **DAAD-NSF:** mutual exchange program.

Thank you very much for your attention.

Collaboration

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- Dr. A. Honecker (Uni Braunschweig).