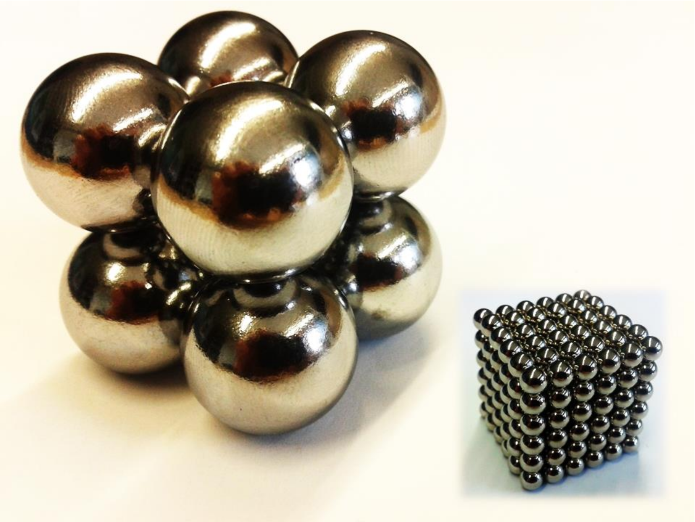
Ground state of a cuboidal dipole cluster animated with a Python script.



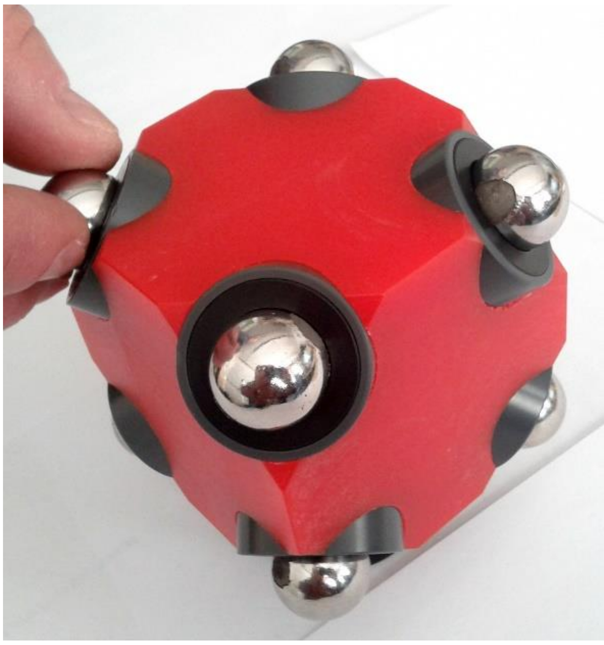
The ground state of a **cuboidal dipole cluster** is animated with the Python program named dipole_cube_animation_1.1. For details of the physics see: Phys. Rev. B 98, 214424 (2018), or https:// doi.org/10.48550/arXiv.1809.08081 and Refs. cited therein. Note that the interactive gallery of the dipole cube listed there moved to https://formaldesign.net/archive/cube_gallery/index.html.

In Version 1.1 the inner structure of the program has been adapted to the dipole cluster relaxation code described in T. Friedrich, I. Rehberg, R. Richter, Comment on "Self-assembly of magnetic balls: From chains to tubes", Phys. Rev. E 91 (2015) 057201 , and provided now within the module "dipole_cube_tools.py" with the enclosed file "dipole_cube_animation_1_1.zip".

The code is tested with Python 3.9.13, as downloaded from: https://www.anaconda.com/download/#windows.

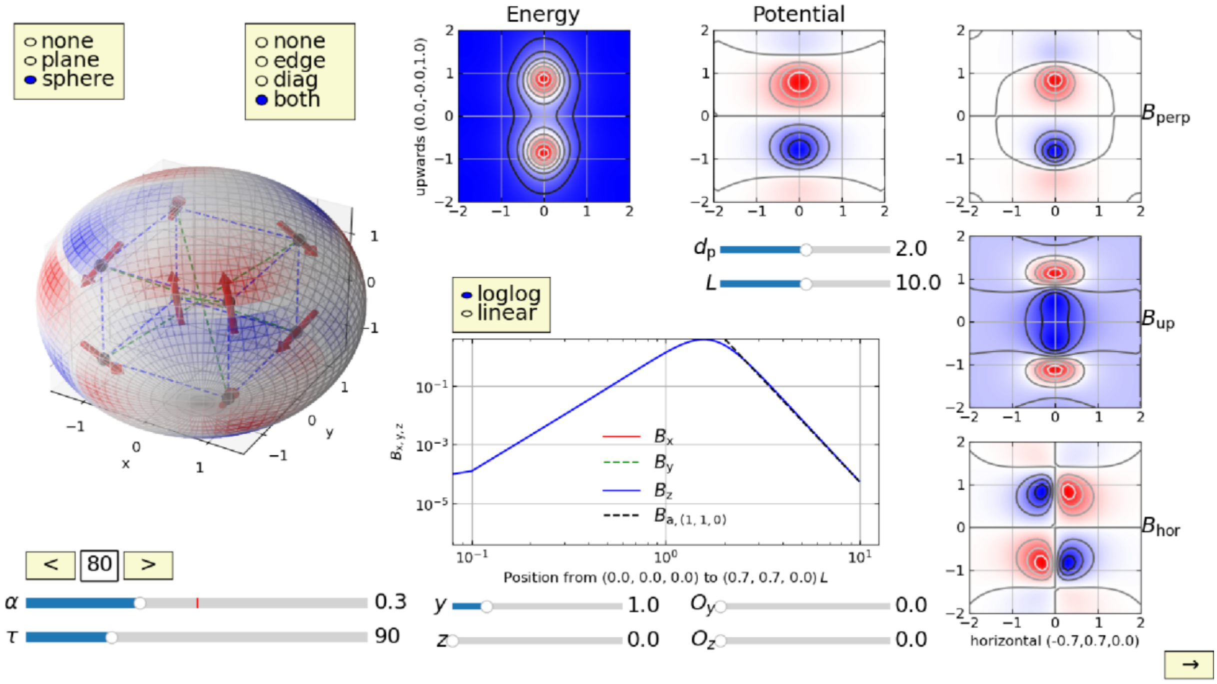
I gratefully acknowledge and highly recommend the use of Spyder IDE, more precisely: * Spyder version: 5.2.2 None, * Python version: 3.9.13 64-bit, * Qt version: 5.9.7, * PyQt5 version: 5.9.2, * Operating System: Windows 10.

To get started, unzip the files and run "dipol_cube_main.py" on the upper directory.



An experimental realization of the continuous ground state animated in the python script provided here.

The animation comes with 2 figures, below is a screenshot from the first one:

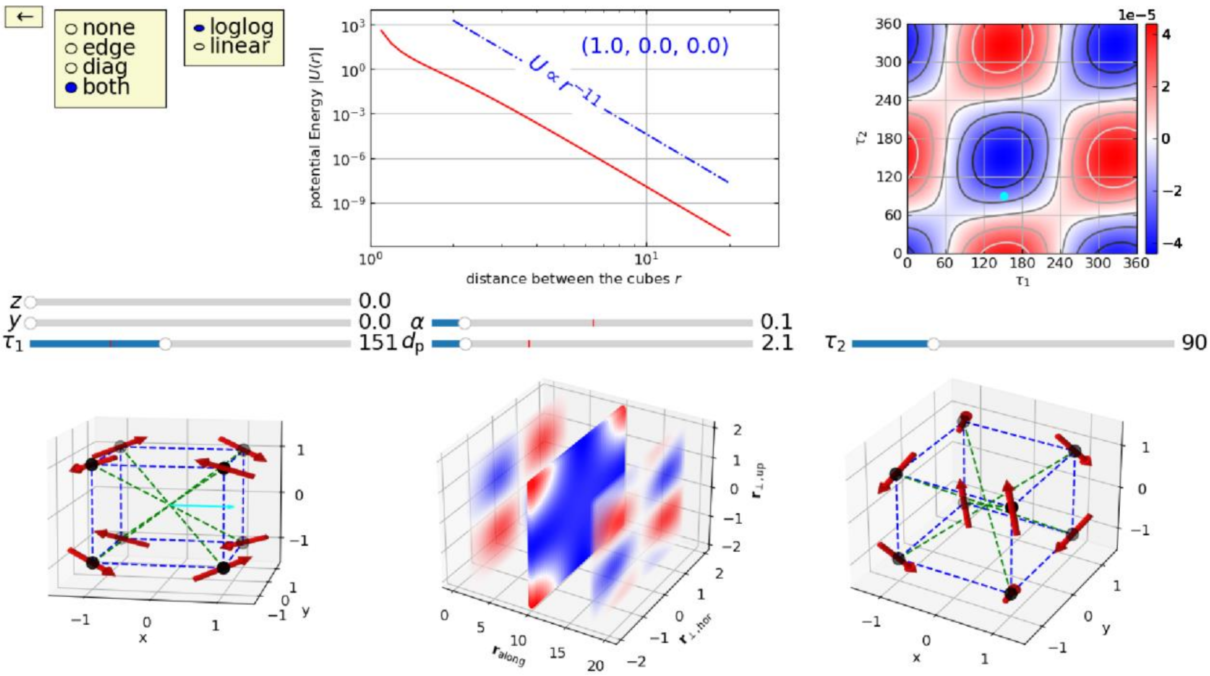


- The 3d-figure on the left hand side shows the orientation of the dipoles in the continuous ground state. The slider τ varies that state. The edges and space diagonals of the cube can be added as guides to the eye with the "none, edge, diag, both" radio button.

  Additionally, a component of the magnetic induction is shown on a plane or spherical surface (as determined by the radio button on the left upper side), precisely the field component perpendicular to that surface. The α-slider determines the transparency of both surfaces.

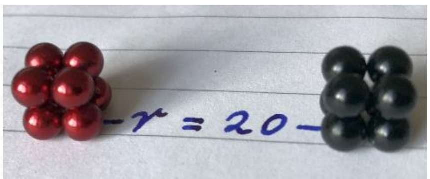
  > Sphere: Its spatial resolution of the can be adjusted with 2 buttons "<" and ">" within the range 10 to 360 (80 in this screenshot), which has to be chosen as a compromise between the artistic impression and the speed of the calculation.
  >
  > Surface: It is chosen perpendicular to the cyan arrow shown inside the cube. Its direction and origin is changed with the four sliders in the lower middle part.

- The figure in the middle shows the three ***B***-field components along the direction ***r*** as indicated by the cyan arrow. They are shown on either a linear or a loglog-scale, switchable with the "loglog, linear radio button". The absolute value B_a along the (1, 1, 0) direction is shown as a reference.
- The remaining Figs. 3-7 show aspects of the magnetic field within the plane perpendicular to that direction, at a finite distance d_p as determined by the d_p -slider.
- The button→ on the lower right hand side leads to the second figure, shown on a new page.



A screenshot from the second figure. Here two cubes are manipulated individually with the corresponding τ sliders. The coordinate systems of the 2 cubes are parallel to each other. For the animation, the center of the second cube is located at a fixed distance of 20 along the ***r*** –direction indicated in cyan color. ***r*** can be manipulated with the y, z-sliders. The remarkable feature of the interaction between both cubes is the decay of the interaction potential with the 11th power. The upper plot illustrates this on a semi-logarithmic or linear scale. While that power is robust for all combinations of τ_1 and τ_2, both the sign and the prefactor are a function of τ_1 and τ_2 as indicated by the plot on the upper right hand side.

The lower middle plot illustrates that interaction further for a fixed distance of 20 between the cubes centers, measured along the direction of the cyan arrow ***r***. Here the coordinate system is chosen such that the x-axis is parallel to the cyan arrow ***r*** shown in the center of the left cube. The 3 planes from the left (right) cube. The plane in the middle denotes the component of the Maxwell stress tensor, such that the integral over this plane (extended to infinity) gives the strength of the force component $\boldsymbol{F}_{\text{along}}$ between the cubes.



The d_p-slider indicates the distance of the planes showing the potential from their corresponding cube, and thus determines the distance between the planes. The transparency of both planes is set with the α-slider, while the middle "Maxwell"-plane is fixed to α=1.

The ← button on the upper left hand side leads back to the first figure.

Cite as: Rehberg, Ingo. (2022). Python code for the animation of a cubic dipole cluster (Version 1.1). Zenodo. https://doi.org/10.5281/zenodo.6484442