Karlsruher Institut für Technologie
Institut für Theorie der Kondensierten Materie

Übungen zur Theorie des Magnetismus Sommersemester 16

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1. Tetragonal symmetry (10 Punkte)

In the lecture the symmetry group of an octahedron was considered. Following this example, we consider the tetragonal symmetry in this exercise. This symmetry arises for a rectangular prism whose base is a square of side length a and its hight is $c \neq a$. Alternatively it arises for an octahedron stretched along one of its high symmetry directions.

(a) Enumerate the group elements and the conjugacy classes.

(b) Determine the number of irreducible representations and their dimensionality.

(c) Construct the character table, and find the corresponding basis states.

(d) What happens to the irreducible representations of the octahedral group when the symmetry is lowered to tetragonal?

Now, we will consider Cu^{2+}-ions in a crystal field with tetragonal symmetry. The Cu^{2+}-ion has 9 electrons in the $3d$-shell, which is the only partially filled shell.

(e) Distribute the electrons over the available levels.

(f) Determine the lowest-order corrections for weak spin-orbit coupling to the ground state wave function and the ground state energy. Is the ground state degenerate? (Hint: It is advantageous to describe Cu^{2+} with one hole instead of 9 electrons.)

(g) Now, switch on a magnetic field in an arbitrary direction and determine the anisotropy of the Zeeman splitting.