Detector Setup of the VIP2 Underground Experiment at LNGS

Johann Marton* and Andreas Pichler*
(on behalf of the VIP/VIP2 collaboration)

*Stefan Meyer Institute for Subatomic Physics, Vienna, Austria

**Abstract**

In 1925 Wolfgang Pauli formulated the Pauli Exclusion Principle (PEP) explaining the shell structure of atoms. It turned out that this principle is valid not only for electrons - it is valid for all fermions, i.e. particles with half integer spin. In spite of the overwhelming success of the PEP in explaining many features of nature, a loophole-free proof cannot be given up to now.

A small violation of the PEP is qualitatively described by the parameter \( \beta \), which was introduced by Ignatiev and Kuzmin [1]. The creation operator \( \hat{a}^+ \) acting on the vacuum state \( |0\rangle \) creates a state filled with one electron \( |1\rangle \). The same creation operator acting on the state \( |\beta\rangle \) creates a state of the form \( |\beta| \hat{a}^+ |0\rangle \), with the state \( |\beta\rangle \) being a Pauli violating state with double occupation. The parameter \( \beta \) is very small.

For \( \beta = 0 \) one arrives at Fermi-Dirac statistics. The parameter \( \beta \) is very small. A small violation of the PEP is qualitatively described by the parameter \( \beta \), which was introduced by Ignatiev and Kuzmin [1]. The creation operator \( \hat{a}^+ \) acting on the vacuum state \( |0\rangle \) creates a state filled with one electron \( |1\rangle \). The same creation operator acting on the state \( |\beta\rangle \) creates a state of the form \( |\beta| \hat{a}^+ |0\rangle \), with the state \( |\beta\rangle \) being a Pauli violating state with double occupation. The parameter \( \beta \) is very small.

The number of possible photons from these transitions, which are identified by their energy, is used to set an upper limit for the probability for a violation of the PEP.

### The VIP2 Setup

The VIP2 setup contains the Silicon Drift Detectors working as X-ray detectors. They are mounted close to a copper target, through which the high current flows. Target and detectors are surrounded by scintillators used as active shielding.

### Preliminary Results and Outlook

The VIP2 experiment has taken over 180 days of data in the Gran Sasso underground laboratory (LNGS). With these data, the Pauli Exclusion Principle could be tested with unprecedented precision.

With planned improvements (e.g. lead shielding, new detectors), the goal of setting a new upper limit for the violation of the PEP to \( 10^{-31} \) will be reached after 3 years of data taking or else a violation of the PEP will be discovered.

### References


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