# Orbital magnetism and 3$d$ spin-orbit interactions - from the heresy to spintronics

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It is worth to remind that, say, 20 years ago, not saying about 30 or 40 years ago, magnetism of 3$d$ compounds was discussed as the spin-only magnetism (with the quenched orbital moment) and the 3d electronic stucture was shown as a wide feature-less 1-3 eV band. The orbital physics is closely related with the crystal-field approach for undertandings of magnetic and electronic properties of 3d-atom compounds. The crystal-field approach is a benchmark of the localized paradigmat in theoretical description in contrast to band theories with continuous energy bands wide by 1-3 eV, whereas CEF operates on discrete atomic-like states. For such understanding we have developed 25 years ago the Quantum Atomistic Solid-State Theory (QUASST) [1] (PRL LW7456) pointing out the preservation of discrete electronic states of open shell 3$d$ /4$f$/5$f$ atoms in solids resulting from crystal-field and spin-orbit interactions. In 30May1997 we have submitted to PRL LE6925 "Relativistic effects in 3$d$ ions" [1] and 8Jun1999 PRL LF7313 "Orbital moment in NiO" [2]. They have been rejected with arguments: that the 3d s-o energy is weak and its effect is not seen. With my obstinate appeals, especially about the first-time calculated orbital moment in NiO (LF7313) and about importance of the s-o interactions in 3$d$-ion compounds (LE6925) with revealing the zero-moment of the $3d^1$ ion, the Editor-in-Chief APS dr M. Blume undertook 7 March 2000 the discrimination decision for my PRL/PRB submissions. Then for the PRL scientific responsibility I have proposed the scientific bet for 1 mln USD from PRL side and 300 USD my-side (arXiv:0005358 at the end). By last 26 years I am making practically only submissions to PRL. They are registered and, according to me, are under the APS law protection.

After 25 years I am very satisfied - we could prove the physical importance of the 3$d$ spin-orbit interactions and for the first time we have calculated orbital moment in NiO, FeO, CoO, $FeBr_2$ and $LaCoO_3$. Thin layers with 3$d$ atoms become the promissing spintronics materials. In $LaCoO_3$ we have revealed for the first time the formation of the non-magnetic (so-called low-spin) state of the Co ion usually forming strong-magnetic state. Recently we are working on 4$d$ and 5$d$-ion oxides (arXiv:2212.06722) getting within the QUASST approach very promissing physical results but as the the biggest achievement I recognize the discrimination decision of PRL-Editor-in-Chief confirming the novelty of my original idea about 3$d$ orbital moment in NiO and the importance of 3$d$ spin-orbit interactions already 25 years ago.

**References:**

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