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The atomic nucleus as a bound system of $3A$ quarks

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Yukawa's meson theory of nuclear binding suffers from serious shortcomings, some of which are revealed here. To remedy the situation, it is necessary to take a closer look at the nucleus as a bound system of quarks based on an effective theory derived from quantum chromodynamics in the low-energy limit. We review some models that embody essential features of the desired effective theory. The Fermi gas model allows us to understand why the number of d quarks in stable light nuclei is almost the same as the number of u quarks. A modifed bag model reveals the reason for deviation from this rule about the quark composition of stable nuclei heavier than ${}^{40}_{20}\mathrm{Ca}$. This model describes with acceptable accuracy the static properties of a very significant part of stable isotopes. To get the most out of the modified bag model, it is advisable to resort to gauge/gravity duality. In the present context, it is appropriate to adopt a new version of duality: "The dynamical affair inside an extremal black hole located in AdS_5 is mapped onto the corresponding affair of a stable nuclear (or subnuclear) system living in $\mathbb{R}_{1,3}$".
With this version of duality, one can predict the main decay channel of the lightest glueball. Another implication of duality is that it explanains why the periodic table contains a limited number of stable elements. It transpires that there exists a maximum allowable electric charge $Z_{\max}$ of stable heavy nuclei, and, moreover, duality makes it possible to calculate this quantity: $Z_{\max} \approx 82$.

This talk is an overview of the following papers:

1. B. P. Kosyakov, E. Yu. Popov, and M. A. Vronski.
   The bag and the string: Are they opposed?
   Phys. Lett. B 744, 28-33 (2015).
2. B. P. Kosyakov, E. Yu. Popov, and M. A. Vronski.
   Could the static properties of nuclei be deduced from the dynamics of a single quark?
   Eur. Phys. J. A 53: 82 (2017); arXiv: nucl-th/1604.06613.
3. B. P. Kosyakov, E. Yu. Popov, and M. A. Vronski.
   Correspondence between the physics of extremal black holes and that of stable heavy atomic nuclei.
   Class. Quantum Grav. 36: 135001 (2019); arXiv: hep-th/1802.03545.
4. M. A. Vronski, B. P. Kosyakov, and E. Yu. Popov.
   How to detect the lightest glueball.
   JETP 133, 154-160 (2021) [Translated from: Zh. Eksp. Teor. Fiz. 160, 188-196 (2021)]; arXiv: hep-ph/1905.09326.
5. B. P. Kosyakov, E. Yu. Popov, and M. A. Vronski.
   Why is ${}^{208}_{82}\mathrm{Pb}$ the heaviest stable nuclide?
   Eur. Phys. J. C 84: 807 (2024); arXiv: nucl-th/2309.13082.

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