Semi-classical, microscopic approach to the liquid drop model and the emergence of alpha clusters

Zbigniew Sosin , Jinesh Kallunkathariyil

M. Smoluchowski Institute of Physics, Jagiellonian University, Reymonta 4, PL-30059 Krakow, Poland

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An isospin and spin dependent form of the equation of state for nuclear matter will be presented. This form is used for the description of nucleon interaction in a new dynamic model. Preliminary calculations show that the new approach makes possible predicting the alpha structures appearing in the case of the ground state even-even nuclei. The change in the structure of nuclei built on the basis of alpha particles occurring for ^{60}Zn also will be discussed.

Although nuclei are close to 55 orders of magnitude lighter than a typical neutron star, it seems that the state of the material comprising of the above two objects can be determined by the same equation, which is the equation of state (EOS) of nuclear matter. In this case EOS is defined as the average energy per baryon expressed as a function of thermodynamic variables. It would seem that the above statement can be more easily justified for heavy nuclei but using an appropriate form of the equation of state can give good results also for the description of the ground states for lighter nuclei. We arrive at these conclusions using semiclasical, microscopic version of the liquid drop model in which dynamics is governed by EOS.

References

[1] J.Bocki, Y.Boneh, J.R.Nix, J.Randrup, M.Robel, A.Sierk and W.J.Swiatecki Ann.Phys.113(1978)330 26, J.Bocki and W.J.Swiatecki Report LBL-12811(1982)

[2] J. M. Lattimer and M. Prakash, Astrophys. J. **550**, 426 (2001)

[3] Z.Sosin, International Journal of Modern Physics E. Vol. **19**, No. 4 (2010)

[4] M.T. Johnson and J.W. Clark, Kinam **2**, 3(1980)

[5] W. Ritz, Z. Rein. Ang. Math. **135** , (1909)

[6] M. Papa, T. Maruyama and A. Bonasera, Phys. Rev. C **64**, 024612 (2001)

[7] W.von Oertzen, Martin Freer, Yoshiko Kanada_En'yo, **432**, 43-113, (2006)

[8] L.R. Hafstad, E. Teller, Phys. Rev. **54**, 681 (1938)

[9] J. Aichelin, Phys. Rep. **202,** 233 (1991).

[10] A. Ono *et al.*, Prog. Theor. Phys. **87**, 1185 (1992)

[11] H. Feldmeier, Nucl. Phys. **A515**, 147 (1990)

[12] M. Freer (2010), Scholarpedia, 5(6):9652

[13] H.A. Bethe, R.F. Bacher, Rev. Mod. Phys. **8** (1936) 82229