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PERTURBATION THEORY WITH A SOFT CORE TWO NUCLEON INTERACTION

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The realistic soft core two nucleon interaction proposed by Gogny, Pirès and de Tourreil [1] is such that it is not necessary to have recourse to Brueckner theory in treating n-body problems. Therefore, we have used ordinary perturbation theory to calculate the equilibrium properties (i.e binding energy, density, radius and separation energy) of ^{16}O, ^{40}Ca, ^{90}Zr and ^{208}Pb.

The expansion is to second order, using a Hartree-Fock basis which included all states containing up to five modes. Such a basis is definitely large enough to ensure a good convergence even in ^{208}Pb. Unoccupied states are approximated by plane waves. In table 1 we have listed our definitive results concerning first and second order energies per particle, and first order r.m.s charge radii. In nuclear matter, this interaction saturates at $k_F = 1.5\ fm^{-1}$ (at first order), a value which is 10 % above the empirical value. The relative difference between empirical and theorical values of radii never exceed 8 %. For the binding energies, the second order result is 25 to 30 % of the nuclear Hartree-Fock potential energy. Concerning the second order corrections to the single particle energies we have evaluated the two following graphs :

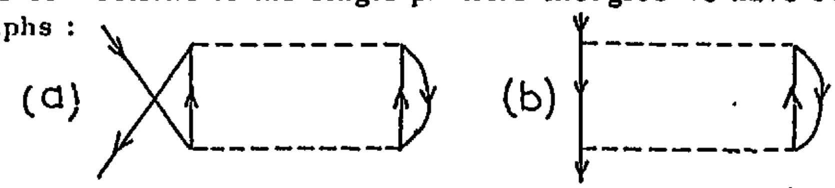

Diagramm (a) enters in the definition of the G matrix ; diagramm (b) results of the change of the Pauli operator. In table 2 we have listed the single particle energy of the last occupied neutron level in ^{16}O, ^{40}Ca, ^{90}Zr.

Finally let us mentionned that nuclear matter properties calculated with the Gogny - Pirès - de Tourreil interaction in the framework of the Brueckner-Hartree Fock theory are very close to those calculated up to second order with the ordinary serie of perturbation [2]. This result is probably a supplementary indication that the perturbation expansion in powers of the interaction should converge rapidly.

[1] D. GOGNY, P. PIRES, R. de TOURREIL ; phys. Letters 32 B (1970) 591.

[2] P. PIRES ; these Orsay (1973).

TABLE 1

	E^{HF}/A MeV	E^2/A MeV	$(E^{HF}+E^2)/A$ MeV	(EXP)	V^{HF}/E^2	r_c fm	(EXP)
^{16}O	- 2.57	- 4.43	- 7	(- 7.98)	25 %	2.85	(2.73)
^{40}Ca	- 2.78	- 6.24	- 9.02	(- 8.55)	29 %	3.48	(3.50)
^{90}Zr	- 2.76	- 7.71	- 10.47	(- 8.71)	30 %	4.11	(4.30)
^{208}Pb	- 2.29	- 7.64	- 9.93	(- 7.87)	27 %	5.10	(5.50)
Nuclear Matter	- 8.	- 8.87	- 16.87		25 %	$k_F = 1.5\ fm^{-1}$	

TABLE 2

	ε^{HF} MeV	ε^2 graph (a)	ε^2 graph (b)	$\varepsilon^{HF} + \varepsilon^2$ MeV	(EXP)
^{16}O	- 12.02	- 4.60	+ 1.18	- 15.44	(- 15.7)
^{40}Ca	- 12.38	- 5.51	+ 1.69	- 16.20	(- 15.6)
^{90}Zr	- 5.66	- 4.03	+ 1.98	- 7.71	(- 12.)