# M2 NPAC — From Nuclei to Stars

Phenomenological aspects : mid-term exam

November 16th 2018

## 1 Course questions

**Question 1**

(a) Remind the definitions of the following quantities: $b$, $p$, $p_+$, $p_-$, $g_+ = p_+/p$ and $g_- = p_-/p$.

(b) Explain how a nuclear interaction with exchange character leads to the observed saturation properties of nuclear matter (use quantities $b$, $p$, $p_+$, $p_-$, $g_+ = p_+/p$ and $g_- = p_-/p$ previously defined and the relative distance between nucleons).

(c) What are the nuclear properties which show saturation?

(d) Give the expression of the nuclear radius in normal saturation condition as a function of $A$ (the number of nucleons) and $b$, explain how the expression is obtained from considerations in (b) above.

**Question 2**

(a) What are the two parameters of the liquid drop model mass formula that shape the valley of stability, explain qualitatively why.

(b) What are the two parameters of the liquid drop model mass formula that define the end of the valley of stability towards large $A$ and $Z$, explain qualitatively why.

**Question 3**

(a) Draw the normal partitions for nuclei with mass $A = 14$, from $Z = 5$ to $Z = 9$ (included). Give isospin and partition numbers $(P, P', P'')$ for each case.

(b) Draw the mass parabola for this chain in a way similar to slide n°21 in slide set n°1. Explain what happens at isospin number 0.

Turn the page.

## 2 Problem

In 1966 Garvey and Kelson [Physical Review Letters 16, 197 (1966)] put forward a new mass relationship suitable to predict the drip line with higher precision than the liquid drop formula can do. The mass relationship is:

$$M(N+2,Z-2) - M(N,Z) = M(N+1,Z-2) - M(N,Z-1) + M(N+2,Z-1) - M(N+1,Z). \quad (1)$$

The authors justified this mass relationship with the following figure:

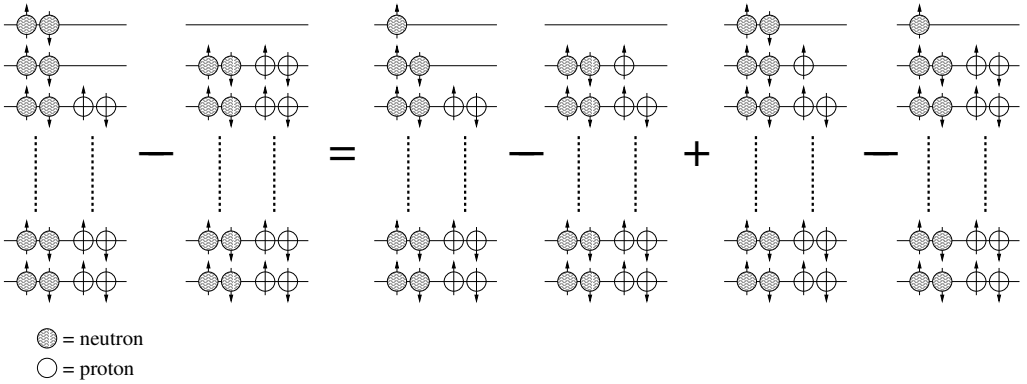


Fig. 1

**Question 4**

Show that this equation is correct from the point of view of the symmetry energy up to a certain approximation, give this approximation. **Hint** Use partition numbering $(P, P', P'')$.

The authors say that the formula can be used for any $A$ provided that:
"$N$ must be equal to or greater than $Z$ and if $N = Z$ they must *not* be odd"

**Question 5**

Justify the reason why if $N = Z$, $N$ and $Z$ must *not* be odd.

**Question 6**

(a) Predict the mass excess of $^{16}$C using the extraction of the evaluated mass table given next page. Compare to the experimental tabulated value of $^{16}$C.

(b) Give a possible reason for the difference observed.