BOUND STATES OF N’S and Ξ’S

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Malfliet-Tjon models of the S-wave NN, NΛ, NΞ, and $\Xi\Xi$ interactions

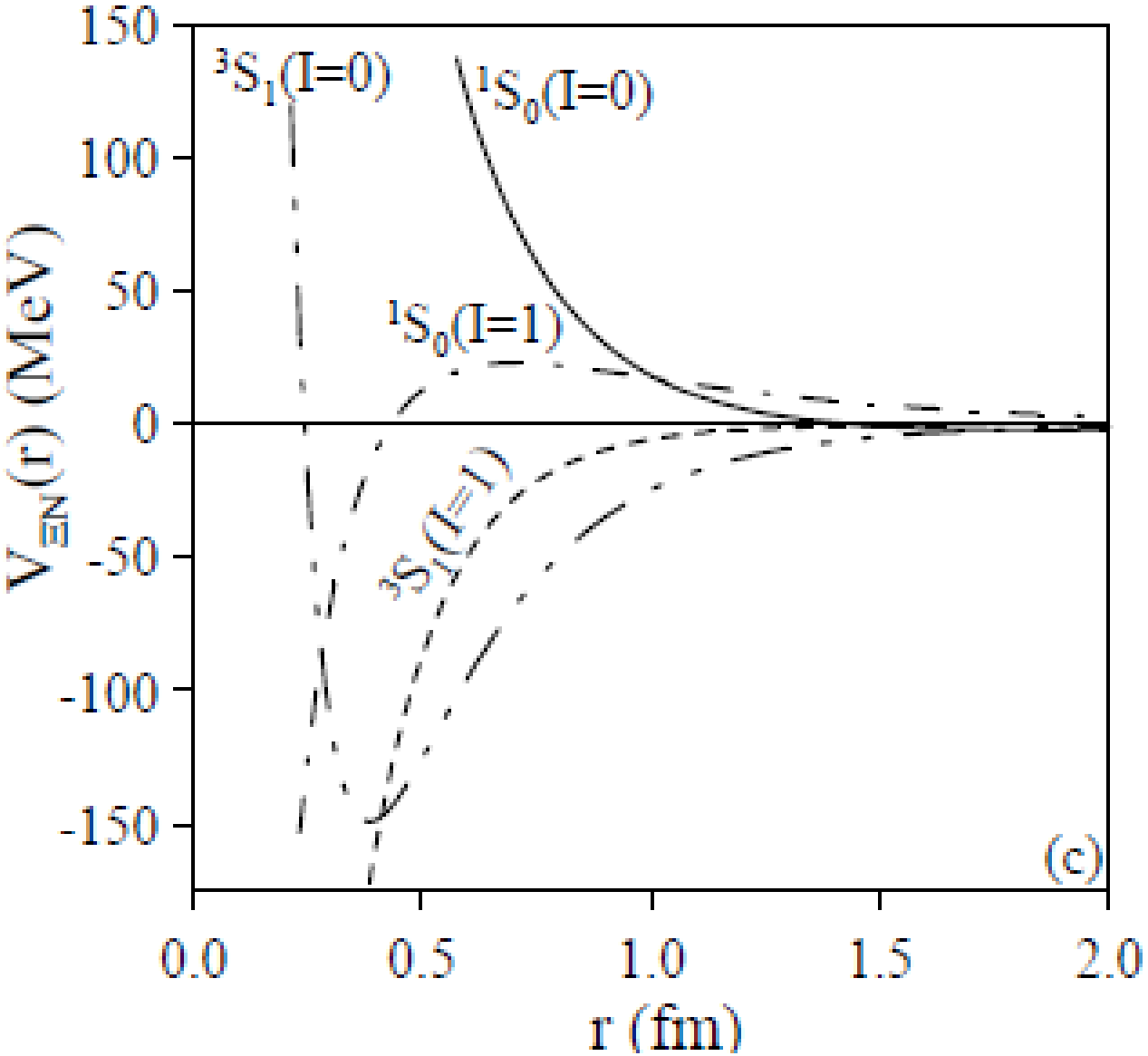
$$V^{ij}(r) = -A\frac{e^{-\mu_A r}}{r} + B\frac{e^{-\mu_B r}}{r}$$

these models give

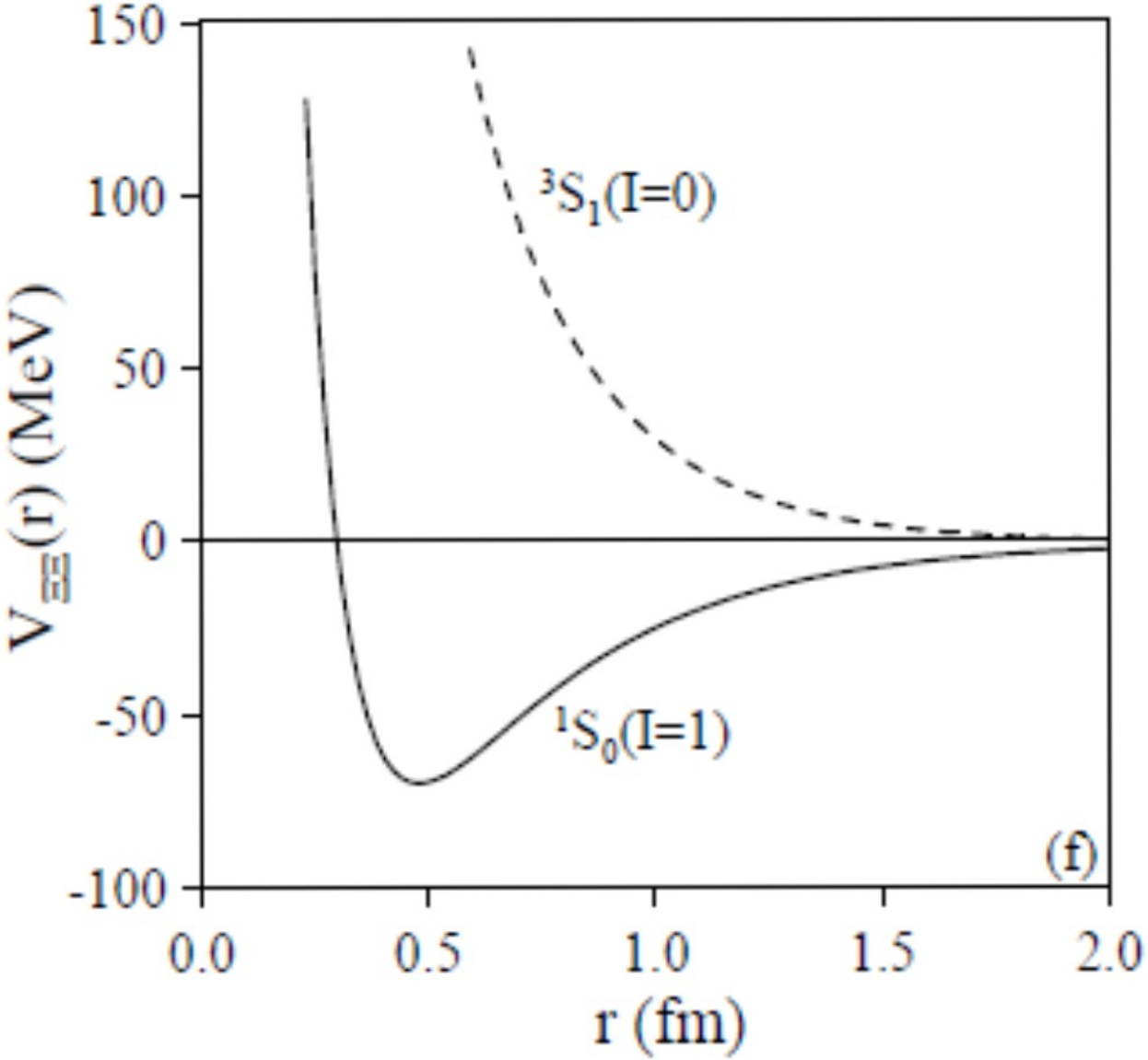
Triton binding energy of 8.3 MeV

Hypertriton separation energy of 0.14 MeV

Nijmegen ΞN S-wave interactions



Nijmegen ΞΞ S-wave interactions



3-body problem, Faddeev eqs.

$$T^{i_i j_i}_{i;IJ}(p_i q_i) = \sum_{j\neq i}\sum_{i_j j_j} h^{i_i j_i; i_j j_j}_{ij;IJ} \frac{1}{2}\int_0^\infty q_j^2 dq_j \int_{-1}^{1} d\cos\theta \, t_{i;i_i j_i}(p_i, p_i'; E - q_i^2/2\nu_i)$$
$$\times \frac{1}{E - p_j^2/2\mu_j - q_j^2/2\nu_j} \, T^{i_j j_j}_{j;IJ}(p_j q_j) \, ,$$

4-body problem, variational method

$$H = \sum_{i=1}^{4}\left(m_i + \frac{\vec{p}_i^{\,2}}{2m_i}\right) + \sum_{i<j=1}^{4} V(\vec{r}_{ij}) \, ,$$

$$\sum_{s'\,s}\sum_{i} \beta^{(i)}_{s3}\left[\langle R^{(j)}_{s'_3}|\, H \,|R^{(i)}_{s3}\rangle - E\,\langle R^{(j)}_{s'_3}|R^{(i)}_{s3}\rangle \delta_{s,s'}\right] = 0$$

Ξ hypernuclei would be unstable due to the decay process

$$N\Xi \longrightarrow \Lambda\Lambda$$

which takes place in the channel $^1S_0$(I=0) for pure S-waves. Thus, a Ξ hypernucleus will be stable if the NΞ channel $^1S_0$(I=0) does not contribute.

The state NN Ξ

$$(I, J^P) = (1/2, 3/2^+)$$

NN $\longrightarrow {}^3S_1(I=0)$

NΞ $\longrightarrow {}^3S_1(I=0), {}^3S_1(I=1)$

B=15.7 MeV

Maximal isospin states

The decay process $N\Xi \longrightarrow \Lambda\Lambda$ can not occur if the Ξ hypernucleus is in a state of maximal isospin, i.e., if it consists only of neutrons and negative Ξ's or only protons and neutral Ξ's . Therefore, these states, if bound, would be stable.

$^{2}_{\Xi}H \quad (1, 1^{+})$ (B=1.6 MeV)

$^{3}_{\Xi}H \quad (3/2, 1/2^{+})$ (B=3.0 MeV)

$^{3}_{\Xi\Xi}He \, (3/2, 1/2^{+})$ (B=4.5 MeV)

$^{4}_{\Xi\Xi}He \quad (2, 0^{+})$ (B=7.4 MeV)

and perhaps a full periodic table of stable Ξ hypernuclei

Normal nuclei

^{2}H (B=2.23 MeV)

^{3}H (B=8.48 MeV)

^{3}He (B=7.27 MeV)

^{4}He (B=28.3 MeV)

etc .

Λ hypernuclei

$^{3}_{\Lambda}H$ (B=2.36 MeV)

$^{4}_{\Lambda}H$ (B=10.52 MeV)

$^{4}_{\Lambda}He$(B=9.66 MeV)

etc .

Kiso event , 2015 (B=4.38 MeV)

$$\Xi^- + {}^{14}N \rightarrow {}^{10}_{\Lambda}Be + {}^{5}_{\Lambda}He$$

unstable bound state, decays

$$\Xi^- + p \rightarrow \Lambda + \Lambda$$

main decay channel

$$(I, J^P) = (0, 0^+)$$