TALENT School Mainz

Few-Body Reactions

Summer 2022

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INTRODUCTION:

For these exercises you should download a ZIP file from the Talent web page `https://indico.mitp.uni-mainz.de/event/279/`. You will find there 3 Jupiter notebooks and input files.
Advice: If you do not manage to solve the problems, you can find the solutions in another ZIP file available on the webpage.

Problem 2.1: LIT in terms of Lanczos coefficients

(a) You are given a file that contains the Lanczos coefficients a_i, b_i with $i = 0, \dots N$ coming from an hyperspherical harmonics calculation for ^{4}He using the dipole operator.
Write a Python script that calculates the Lorentz Integral Transform (LIT) as a continued fraction of the Lanczos coefficients, implementing this formula

$$L(\sigma,\Gamma) = -\frac{1}{\pi}\langle\Psi_0|\mathcal{O}^\dagger\mathcal{O}|\Psi_0\rangle Im\left\{\frac{1}{(z-a_0)-\frac{b_1^2}{(z-a_1)-\frac{b_2^2}{(z-a_2)-b_3^2\cdots}}}\right\}, \qquad (1)$$

where $z = E_0 + \sigma + i\Gamma$.

(b) Plot $L(\sigma,\Gamma)$ vs σ for a fixed $\Gamma = 10$ MeV and a varying number of Lanczos coefficients $N = 100, 200, 300, \dots$. How many Lanczos coefficients do you need to converge the LIT?

(c) Calculate various $L(\sigma,\Gamma)$ for $\Gamma = 1, 5, 10, 20$ MeV and plot them. Discuss your results with your colleagues.

Problem 2.2: Inversion of the LIT

For this exercises, we will discuss two physics examples presented in the Lectures:
(i) ^{4}He photodissociation;
(ii) ^{40}Ca longitudinal inelastic electron scattering.

(a) Use the LIT files which you calculated in Problem 2.1 for the dipole response and the precalculated ones for the longitudinal response, for various Γ. Use a Python script that inverts the Integral transform.
Bonus: If you are proficient in Python, you can also write your own script implementing the least squared fit explained in class.

(b) Invert the LITs using various number of basis function (typically $N = 6-9$). For the dipole, the threshold behaviour should be set to $\omega^{3/2}$. For the longitudinal response, since we sum over several mulitpoles, you can vary this behaviour. Reasonable values are $\omega^{1/2}$, $\omega^{3/2}$.

(c) Compare inversions. Treat the spread between them as a theoretical uncertainty of the method.

(d) Plot your results in comparison to experimental data. Discuss your findings with colleagues.