Project: Lipkin Model

1. Prove the commutation relations for the quasi-spin operators.
2. Plot the eigenvalues of the LM Hamiltonian matrix in the quasi-spin basis for $\varepsilon=1$, $\Omega=14$, $N=14$ as a function of $0<V(\Omega-1)/\varepsilon<2$. Label eigenvalues using the conserved quantum numbers.
3. What happens with the two lowest eigenvalues around $V(\Omega-1)/\varepsilon=1$? Is it reminiscent of something you've seen before?
4. Consider the transition operator

$$\hat{Q} \equiv \hat{K}_x = \frac{1}{2}\left(\hat{K}_+ + \hat{K}_-\right)$$

   What is expectation value of this operator in the ground state?
5. Calculate the transition matrix element of this operator between the ground state and the first excited state as a a function of $0<V(\Omega-1)/\varepsilon<2$.
6. Find the eigenvalues of the LM Hamiltonian matrix in the CI basis (occupation number representation basis) for $\varepsilon=1$, $V=0.1$, $\Omega=2$, $N=2$ and for $\Omega=2$, $N=4$. Benchmark this result using the quasi-spin formalism. Identify quasi-spin and signature quantum numbers. Discuss the result.

Final Project, PHY 981 reporting requirements

- Your report should be structured as a Phys. Rev. C regular article
- For detailed guidelines, see https://journals.aps.org/prc/authors#msprep
- Use revtex 4.2: https://journals.aps.org/revtex
- For editing and typesetting, Overleaf, a collaborative cloud-based LaTeX editor is strongly recommended: https://www.overleaf.com/. There are also other choices, such as TeXShop
- Use your own words. It is *your* scientific report
- Use the structured abstract: http://journals.aps.org/prc/edannounce/PhysRevC.84.030001
- Remember to label figures
- Add references!
- Grammarly, a cloud-based typing AI assistant, can be useful