Weak interference between the 1^- states in the vicinity of α-particle threshold of ^{16}O

M. Katsuma[a,b]

[a] *Advanced Mathematical Institute, Osaka City University, Japan*
[b] *Institut d'Astronomie et d'Astrophysique, Université Libre de Bruxelles, Belgium*

The subthreshold 1^-_1 state at an excitation energy $E_x = 7.12$ MeV in ^{16}O has been believed to enhance the astrophysical S-factor for ^{12}C(α,γ_0)^{16}O. The enhancement seems to originate from strong interference between 1^-_1 and 1^-_2 ($E_x \approx 9.6$ MeV) in the vicinity of the α-particle threshold. However, the weak interference between two states and a resulting small $E1$ S-factor are exemplified with R-matrix theory in this presentation. In my previous reports [1], I have predicted the small $E1$ S-factor at $E_{c.m.} = 300$ keV from the potential model, because non-absorptive scattering results in weak coupling between shell and cluster structure in ^{16}O. In the present example, I utilize the previous results to estimate the reduced α-particle width of 1^-_1 and 1^-_2. In addition, the formal parameters in R-matrix are obtained from an exact expression, including a higher-order correction, because it has been reported that the resonance parameters for 1^-_2 are not appropriately treated in the linear approximation. This correction ensures that the R-matrix calculation corresponds to the experimental data.
In the calculation [2], a large energy shift for the pole of 1^-_2 is expected from the α+^{12}C cluster structure in ^{16}O. The resultant energy of the 1^-_2 pole is found to be located in the vicinity of 1^-_1. This proximity of the poles suppresses their interference, and it consequently makes the small $E1$ S-factor below the barrier (Figure 1). The corresponding results of the β-delayed α-particle spectrum of ^{16}N and the calculated p-wave phase shift of α+^{12}C elastic scattering are consistent with the previous experimental results. The experimental α-particle width of 1^-_2 is also reproduced by the present example.
It would therefore be possible in the R-matrix method that the $E1$ S-factor is reduced from the enhanced value currently expected. At the same time, the reaction rates of ^{12}C(α,γ)^{16}O are expected to be obtained from the direct-capture component, rather than compound nucleus mechanisms.

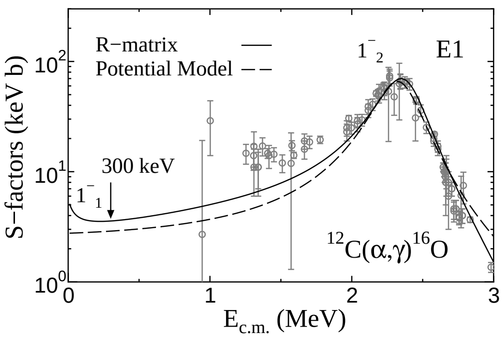

Figure 1. An example of the R-matrix calculation of $E1$ S-factor for ^{12}C(α,γ_0)^{16}O.

References

[1] M. Katsuma, Proc. Nuclei in the Cosmos XIV, JPS Conf. Proc. **14** (2017) 021009; M. Katsuma, Phys. Rev. C **78**, 034606 (2008); ibid. **81** (2010) 067603; Astrophys. J. **745** (2012) 192; PoS(NIC XIII) (2015) 106.

[2] M. Katsuma, arXiv:1701.02848 [nucl-th].