STATISTICAL SIGNIFICANCE OF THE DEVIATION FUNCTION IN A SEARCH FOR RESONANCES

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Resonance phenomena observed in the excitation curves of heavy-ion nuclear reactions are decerned from the normal statistical behaviour due to correlations between different exit channels. Apart from very striking abnormal structures statistical tests must be performed to discriminate the interesting phenomena from statistical fluctuations. It is then important that confidence limits can be specified. We describe here the application of the energy dependent deviation functions and use as an example the excitation functions for the $^{9}Be + {}^{12}C$ system measured by the authors (see fig.1).

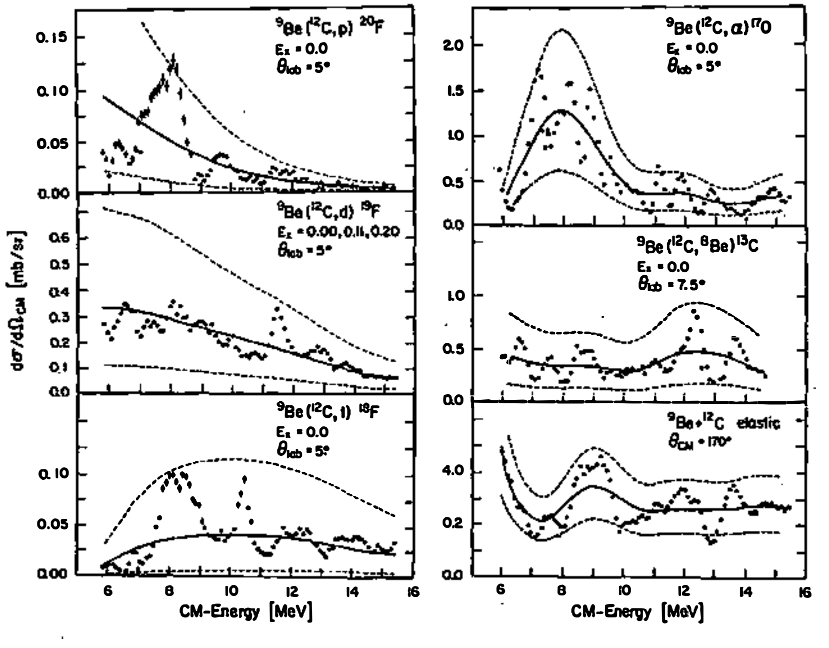

Fig. 1. Excitation functions for the system $^{9}Be + {}^{12}C$

In the presence of a direct reaction contribution d, the relative differential cross sections $x = \sigma(E)/\langle\sigma(E)\rangle$ are distributed according to

$$p(x) = \left(\frac{n}{1-d}\right)^n x^{n-1} \exp\left(-n \frac{x+d}{1-d}\right) \frac{I_{n-1}(2n\sqrt{xd}\,/(1-d))}{(n\sqrt{xd}\,/(1-d))^{n-1}} \qquad (1)$$

The average cross sections $\langle\sigma(E)\rangle$ can be found, e.g., as a running average (solid lines in the right half of fig.1) or, when direct contributions are negligible, as Hauser-Feshbach cross sections (left half of fig.1). n is the number of independent channels and I_n the modified Bessel function. 99 % of the cross sections should lie within the dashed lines in fig.1.

For a set of N independent excitation functions $\sigma_k(E)$ the deviation function is:

$$D(E) = \frac{1}{N} \sum_{k=1}^{N} (x_k(E)-1) \qquad (2)$$

(fig.2). For judging the significance of an observed structure the probability density of D, p(D), must be known. The characteristic function of p(D) can be calculated easily as product of the characteristic functions of the original distributions (1). For the variance one derives immediately

$$\sigma^2 = N^{-2} \sum_{k=1}^{N} R_k(0) \qquad (3)$$

The auto-correlation function for $\varepsilon = 0$

$$R_k(0) = (1 - d_k^2)/n_k \qquad (4)$$

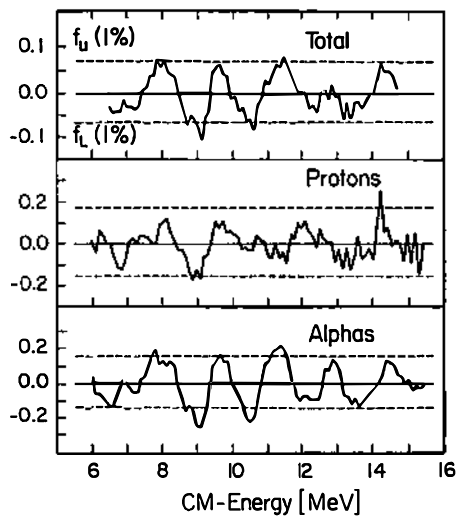

Fig. 2. Deviation functions with upper and lower 1 % fractiles

can be evaluated from the measured excitation functions so that the determination of the variance is free from model assumptions. An exact specification of the 1 % confidence limits requires a knowledge of n_k and d_k, e.g. as a result of a Hauser-Feshbach calculation, and the Fourier transform necessary to find p(D) has to be done numerically (dashed curves in fig.2). Approximately the probability density of D + 1 is the same as that of the cross sections (1), replacing n by $N_{tot} = \sum n_k$ and d by $\langle d_k \rangle$.