Proc. Sixth Int. Symp. Polar. Phenom. in Nucl. Phys., Osaka, 1985
J. Phys. Soc. Jpn. 55 (1986) Suppl. p. 788-789

2.14 Fusion of aligned ^{23}Na with ^{23}Na*)

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*) supported partly by the BMFT, Bonn
a) Alexander von Humboldt Fellow
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The fusion of heavy ions has been the subject of many experimental and theoretical investigations in the last few years[1)]. At low energies the fusion cross-section is almost equal to the total reaction cross section and its behavior is determined by the properties of the entrance channel. At higher energies the fusion cross section starts to deviate from the total reaction cross section and falls drastically below it.

The outstanding problem is to understand this limitation of the fusion cross section. There are two explanations, one related to the entrance channel properties of the two fusing nuclei and the other one related to the compound nucleus properties.

The entrance channel models are based on the specific properties of the projectile and target via their interaction potential and the dissipative forces.

In the compound nucleus models the important feature is the critical angular momentum l_{cr} above which it is impossible to form a compound nucleus. This limiting angular momentum at high excitation energies is given by the socalled statistical Yrast-line[2)].

Fig. 1 displays the results of the measurements of the fusion cross section for different entrance channels leading to ^{46}Ti as a plot of the excitation energy E^* in ^{46}Ti versus the critical angular momentum l_{cr} determined by the sharp cutoff procedure. The observed limitation of the fusion cross section is described quite well by the statistical Yrast-line[3)].

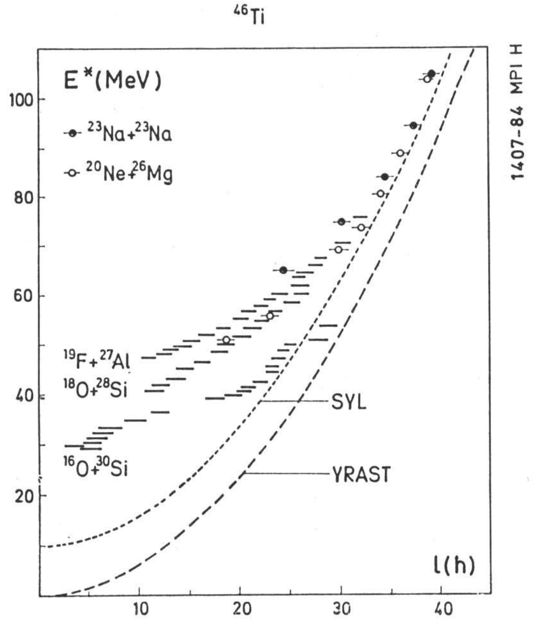

Fig. 1: Excitation energy of ^{46}Ti plotted versus critical angular momentum l_{cr}. The data points are deduced from experimental cross section of evaporation residue like fragments using the sharp cutoff method. Also plotted the Yrast and statistical Yrast lines.

The use of aligned heavy ion beams of deformed nuclei is a new tool to look for entrance channel effects in the fusion process at high energies.

If the concept of the statistical Yrast-line is correct, so that the fusion cross section at high energies is limited by the properties of the compound nucleus, then the tensor analyzing power T_{20}^{fus} should scale as $1/l_{cr}^2$.

There exist also predictions[4] for T_{20}^{fus} within the socalled surface friction model[5]. This is an entrance channel model which calculates the classical trajectories for a given potential.

Fig. 2 displays the predictions for T_{20} of the surfacte friction model for various values of the tangential friction coefficient.

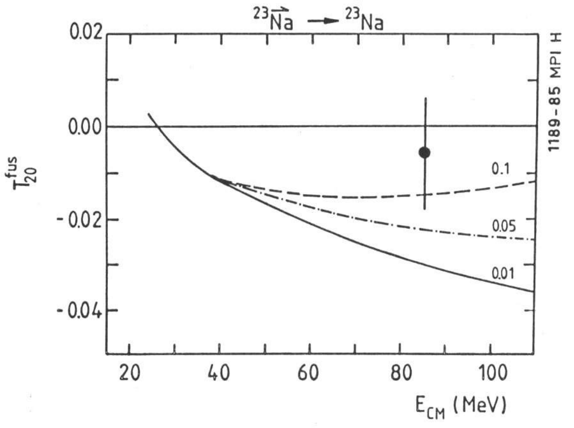

Fig. 2. Tensor analyzing power T_{20} for the fusion of $^{23}\vec{Na}$ with ^{23}Na with predictions of the surface friction model for various values of the tangential friction coefficient Kp[5].

Using the Heidelberg polarized ^{23}Na beam[6] the tensor analyzing power T_{20}^{fus} was measured at the bombarding energy E_{Lab} = 170 MeV achieved by the MP-tandem post-accelerator combination.

The analyzing pcwer T_{20}^{fus} turned out to be zero (T_{20}^{fus} = 0.0060 $\pm$ 0.0125) within the error bars, in good agreement with the concept of the statistical Yrast-line.

Despite its relatively large error bar (but note scale!) our experimental result does not agree with the prediction for the commonly used value of its coefficient of tangential friction (Kp = 0.01 $\cdot$ 10^{-23} s/MeV). The present calculations took into account only the static deformation of the ^{23}Na projectile, but no dynamical processes such as excitations. From other experiments it is well known that such processes might change the results considerably[3].

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