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**Laboratory**: FLNR, sector 6, ACCULINNA separator group
**JINR-theme:** (03-5-1094-2010/2016): Synthesis of new nuclei, nuclear structure study for nuclei close to nucleon drip-line.
**Subject of the exercise**: **Study of sub-barrier fusion systematics on the ground of a recently introduced fusion Q-value rule.**

Exercise for 1 person.

## Introduction

Fusion of two atomic nuclei occurs when the interacting bodies can overcome the barrier formed by the sum of the attractive nuclear and the repulsive Coulomb and centrifugal potentials. If the centre of mass (c.m.) of kinetic energy is below the barrier height, classically forbidden fusion can occur as an instantaneous act of barrier quantum tunnelling. The tunnelling probability depends on the barrier parameters. However, the fusion cross-sections of some nuclei, despite being isotopes of the same element and thus having almost the same barrier, very often differ dramatically. This effect, known as sub-barrier fusion enhancement, is hitherto explained as being caused by the intrinsic properties of individual nuclei, their susceptibility to collective excitations, and nucleon or cluster transfers. The above effects are taken into account through couple channels calculations (CC) individually for given pair of fusing nuclei.

Recently a new treatment of the sub-barrier data has been proposed [1,2]. It is the fusion Q-value which governs behaviour of the fusion cross-section below the Coulomb barrier. It is in fact a phenomenological way to generalize a vast body of fusion data. On the ground of this approach we have found simple and surprising correlations with many experimental fusion data sets. This approach is an unusual one for majority of sub-barrier community. Typical objections have been raised in a Comment [3] to Ref.[1] and discussed in the reply to that comment [4].

## A task for practitioner

A practitioner has to make several figures out of selected numerical fusion data (www.nrv.jinr.ru ). In these figures experimental c.m. energy is replaced by a known reduced energy parameter. We expect that by means of this energy reduction the resulting various fusion data will become close to a universal curve, independently on fusion system and specific nuclear properties of interacting nuclei.
The aim of that study is a critical evaluation of the data. Possible data disagreement with a general trend could be caused either by a limitation of the proposed method or by data inconsistencies. It would be interesting to point out the data which are questionable ones.

## Comment

The proposed work is not even a theoretical one; it is a play with available and published data. Results of that study, if conclusive, could be publishable.

## Requirements

A computer with a text editor like Ultra-Edit, dealing with Origin program to make figures, reading these 4 referred papers, a few pages each, prior to an essential work.

## References:

[1] R. Wolski, Phys. Rev. C **88** 041603(R) (2013).
[2] W.W. Qu et al., Phys. Rev. C **90**, 064603 (2014).
[3] A.V. Karpov et al. Phys. Rev. C **93**, 019801 (2016).
[4] R. Wolski, Phys. Rev. C **93**, 019802 (2016).