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Possible Dependence of Dissipation Strength on Angular Momentum*

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Abstract A comparative analysis for dissipation behaviors of nucleus ^{110,112}In formed in 130MeV ^{3}He+$^{\rm nat}$Ag reactions and ^{111}In populated via ^{84}Kr on ^{27}Al collisions at 890 and 714MeV suggests that nuclear dissipation strength may have an angular momentum dependence besides the known deformation and/or temperature dependence.

Key words dissipation strength, angular momentum, light fissioning systems

1 Introduction

The nature and magnitude of nuclear dissipation is the current subject of great experimental and theoretical interests[1]. An essential conclusion drawn from these studies concerning heavy fissioning systems is that dissipation depends on the deformation[2] and/or temperature[3]. In this paper we attempt to search for new property of dissipation by analyzing data of delayed fission involving light systems.

2 Data analysis and discussions

Three analyzed reactions are listed in Table 1. The mean angular momenta contributing to fission reactions, $L_{\rm ave}$, are taken from experiments (denoted as $*$) if available, otherwise they are estimated as the largest fusion angular momenta predicted by Bass model[4]. Nuclear temperatures are obtained according to formula $T=\sqrt{(E^*-E_{\rm rot}(L))/a}$, where rotational energies $E_{\rm rot}(L)$ are calculated by a rotating finite range model[5], and level density parameter is chosen as $a=A/9$ with A being the mass number of the fissioning systems. The last column in Table 1 denotes whether dissipation is introduced to explain experimental date.

Table 1.

$E_{\rm lab}$	reaction	CN	E^*	$L_{\rm ave}/\hbar$	T/MeV	dissipation
130	^{3}He+$^{\rm nat}$Ag[6]	^{110,112}In	139	25	3.27	No
890	^{84}Kr+^{27}Al[7]	^{111}In	200	72*	3.25	Yes
714	^{84}Kr+^{27}Al[8]	^{111}In	152	71*	2.61	Yes

As is seen from Table 1, a study for the excitation function of complex fragment emission indicated that for ^{110,112}In nucleus, no fission delay effect was observed[6] in 130MeV ^{3}He on $^{\rm nat}$Ag collision, while in ^{84}Kr+^{27}Al $\longrightarrow$ ^{111}In reaction at 890 and 714MeV[7, 8] the enhanced pre-scission light charged particles clearly showed the necessity of introducing dissipation. How to understand these experimental results? From the opinion of standard statistical models (as embodied in GEMINI[9], CASCADE[10], PACE2[11] codes, etc.), the decay characteristics of a compound nucleus are mainly determined by the nuclear size, temperature and angular momentum, etc. However, statistical codes[9—11] fail to predict the pre-scission particle multiplicity correctly after the excitation energy of the compound system rises to a certain value. To explain this failure, nuclear dissipation was introduced. Paul et al.[3] reproduced emitted γ-ray

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data in fission by assuming an increasing dissipation with temperature. Fröbrich et al.[2] also successfully reproduced a lot of data of pre-scission particle multiplicities and fission probabilities by assuming that dissipation is rather weak inside the saddle point and becomes stronger at larger deformations. We notice that these results are based on an analysis for the data of heavy fissioning systems ($A\sim200$). It is interesting to investigate particle emission for some nuclei with $Z>90$ near a long lifetime line[12].

We first use these viewpoints to analyze the present data of light In systems. From Table 1 one can see that the former two reactions produce In compound nuclei with almost the same size ($A\sim110$) and temperature ($\sim$3.3MeV), which means that the observed difference of dissipated behavior for these two In systems cannot be explained using the opinion of temperature-dependent dissipation[3]. This conclusion is further strengthened because dissipation in the third reaction is still necessary in order to interpret the particle multiplicity data, although this reaction results in lower nuclear temperature ($\sim$2.6MeV) as compared with that in the first reaction. Moreover, the In nucleus is quite light, so its scission configuration closes to the saddle point[2, 13], which means that the change of dissipation behavior of these In systems also cannot be account for using the viewpoint of deformation-dependent dissipation[2] if a rather smaller dissipation inside saddle is considered.

However, we notice that a very larger average fission angular momentum (over $70\hbar$) is involved in the Kr+Al reaction than that in the He+Ag reaction (less than $25\hbar$). This seems to imply that dissipation strength depends on the angular momentum. Although this interpretation is somewhat qualitative, it is supported by the linear response theory, which proposes that two-body dissipation could be much larger in a high rotational frequency[14]. It should be pointed out that we do not find an alternative explanation for the present In data.

3 Summary

In conclusion, the analysis of In data suggests that dissipation strength may have an angular momentum dependence besides the known deformation and/or temperature dependence.

References

1 Fröbrich P. Prog. Theor. Phys., 2004, **154**(Suppl.): 279
2 Fröbrich P, Gontchar I I. Phys. Rep., 1998, **292**: 131
3 Paul P et al. Annu. Rev. Nucl. Part. Sci., 1994, **44**: 55
4 Bass R. Nucl. Phys., 1974, **A231**: 45
5 Sierk A J. Phys. Rev., 1986, **C339**: 2039
6 Moretto L G et al. Phys. Rev. Lett., 1995, **74**: 3557
7 Nakagawa T et al. Nucl. Phys., 1995, **A583**: 149
8 JIANG D X et al. Chin. Phys. Lett., 1998, **15**: 95
9 Charity R J et al. Nucl. Phys., 1988, **A483**: 371
10 Pühlhofer P. Nucl. Phys., 1977, **A280**: 267
11 Gavron A. Phys. Rev., 1980, **C21**: 230
12 XU C, REN Z Z, WANG Z J. HEP & NP, 2005, **29**(7): 673 (in Chinese)
(许昌, 任中洲, 王再军. 高能物理与核物理, 2005, **29**(7): 673)
13 YE W et al. Z. Phys., 1997, **A359**: 385
14 Pomorski K, Hofmann H. Phys. Lett., 1991, **B26**: 164

核耗散强度对角动量的可能依赖性*

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摘要 对130MeV ^{3}He+^{nat}Ag→^{110,112}In和890以及714MeV ^{84}Kr+^{27}Al→^{111}In反应中的核耗散行为进行了一个比较分析. 数据分析建议除了已知的温度和/或形变依赖性以外, 核耗散强度可能对角动量也存在一定的依赖性.

关键词 核耗散强度 角动量 轻裂变系统

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