

THE STATISTICAL ANALYSIS OF EXPERIMENTAL AND THEORETICAL  
GOLD NUCLEAR LEVELS

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I. INTRODUCTION

When many excited states of a given nucleus are known, it is possible to apply a statistical method of analysis to the cumulative number of levels,  $N(E)$ , with an excitation energy equal to or lower than  $E$ . The step function  $N=N(E)$  can be represented by a smooth curve with a continuous derivative,  $\rho_1=dN/dE$ , except for the lowest lying levels. Furthermore, the average nuclear temperature  $T$ , defined (see |1|) by the relation  $T^{-1} = d(\log N)/dE$ , remains constant up to the energy  $E_m$ . For higher energies, in the neutron capture resonance region, the nuclear temperature  $\tau$ , defined by the relation  $\tau^{-1} = \rho_2/N(E)$ , is energy dependent but it is possible (see |2|) to fit tangentially at  $E = E_m$  the low energy and the high energy  $N(E)$  distributions. This method was applied extensively by Gilbert and Cameron |2| to many nuclei including a few gold isotopes. However, in the statistical analysis of these nuclides, only few levels were used (12 levels in  $^{193}\text{Au}$  and 15 levels in  $^{195}\text{Au}$ ). The recent establishment of complex experimental level schemes for the same isotopes (74 levels in  $^{193}\text{Au}$  and 31 levels in  $^{195}\text{Au}$  |3-5|) and other lighter ones |6-8| suggested a new statistical analysis of these states.

In the present report, we compare the odd mass gold negative parity experimental level distributions, looking for systematic deviations between them (either due to experimental data missing or eventually differences

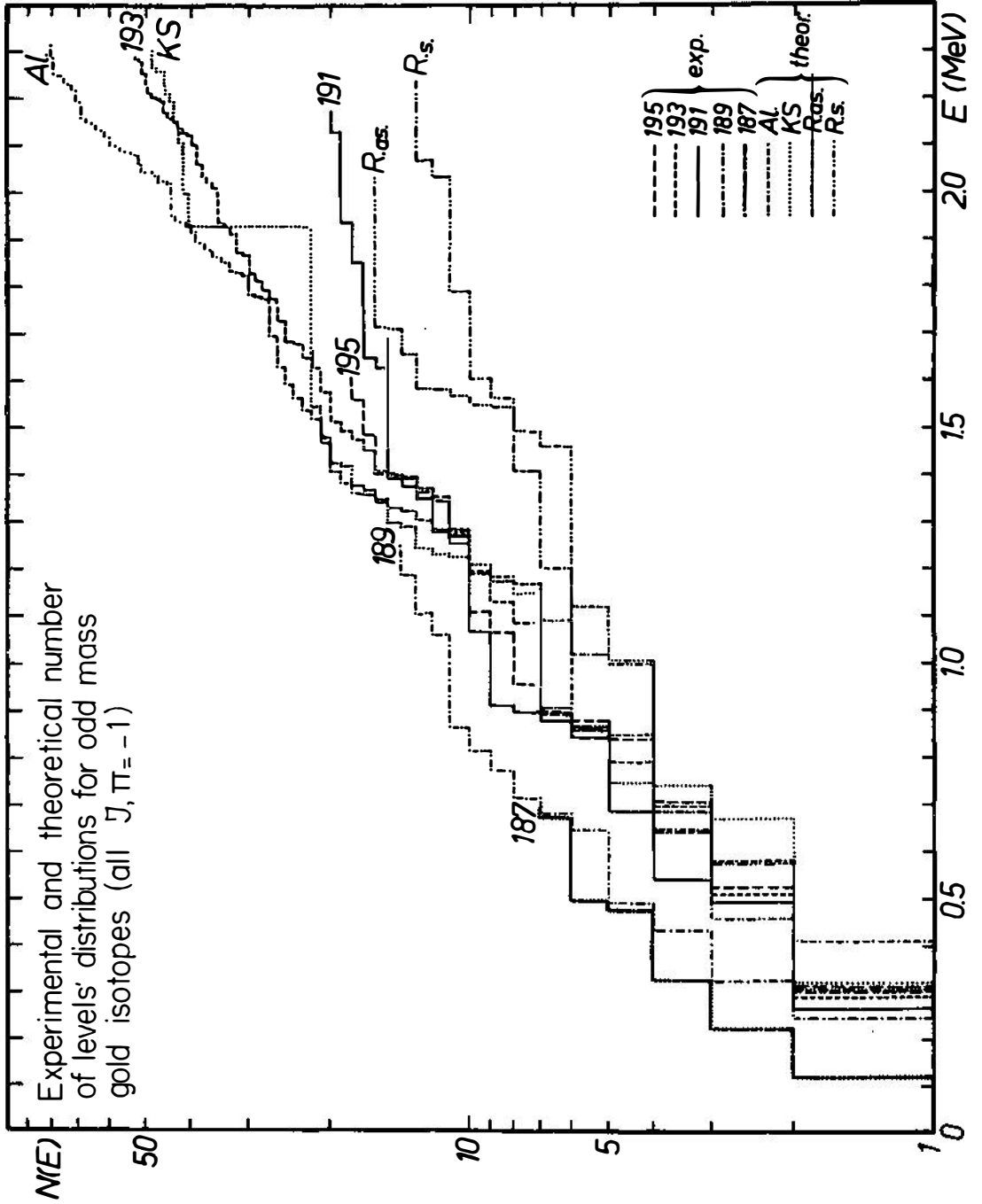


Fig. 1

Fig. 1. Experimental number of negative parity levels distributions of odd mass gold isotopes ( $187 < A < 195$ ) compared with theoretical distributions predicted for  $^{193,195}\text{Au}$  by the Alaga (Al), Kisslinger-Sorensen (KS) and particle rotor asymmetric (Ras) or symmetric (Rs) models.

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... nuclear structure of neighbouring isotopes). Furthermore, a similar statistical analysis is made for the theoretical levels predicted by different models with spherical as well as deformed basis. These theoretical distributions are compared with the experimental ones in order to find the most complete theoretical overall description. Finally, the Gilbert-Cameron's high energy distributions, fitting the available data on the neutron capture resonance, are compared with the experimental and theoretical low energy distributions.

## [. STATISTICAL ANALYSIS

### A. Low energy distributions of the odd mass gold negative parity states

The experimental and theoretical number of levels distributions of the odd mass ( $187 < A < 195$ ) gold negative parity states are represented in fig. 1. The experimental data are taken from the most recent investigations [3-8] and the theoretical data were obtained from new calculations made with the Alaga [9-10] and the Kisslinger-Sorensen [3,9-10] models or previous results with the one particle-symmetric [11] and asymmetric [12] rotor models. All these calculations deal with the description of  $^{193,195}\text{Au}$ . From the comparison of these distributions, several conclusions can be drawn:

1) the gold 191, 193, 195 distributions are quite similar for excitations lower than 1.4 MeV. At higher

energies, the  $^{193}\text{Au}$  distribution is systematically higher than all the others, This is due either to lower E.C. decay energies ( $^{195}\text{Hg}$ ) or missing of high energy levels connected with experimental difficulties ( $^{191}\text{Hg}$ ).

2) The systematic excess of  $^{187,189}\text{Au}$  distributions, compared with those of the heavier isotopes, can be attributed to the appearance of a new band built upon a  $9/2^-$  state. Indeed, the excitation energies of all the components of this band decrease sharply from the heavier to the lighter isotopes |13|.

3) The Alaga model predicts a  $N(E)$  distribution very similar to the  $^{193}\text{Au}$  experimental one. The systematic deviation, observed between these two distributions for excitation energies larger than 2 MeV, is due to experimental levels missing (60 high energy unclassified  $^{193}\text{Au}$  transitions).

4) The Kisslinger-Sorensen distribution is very close to the Alaga one until  $\sim 1.5$  MeV. However, the strong disagreement of the theoretical and experimental distributions at higher energies, can be attributed to the influence of the neglected three quasi-particle configurations which are predominant in this energy region.

5) The particle-rotor distributions, including the rotational (or quasi-rotational) band constructed on the  $1h_{11/2}$  isomeric state, are considerably lower than the experimental ones. Such deviations could be reduced, in the lighter isotopes, introducing the  $9/2^-$  band. However, the high experimental level densities of the 187 to 195 odd mass gold isotopes clearly show that these nuclides have a more complex structure than predicted by the rigid rotor models.

#### B. Low and high energy distributions of Hg, Au and Pt

Using the experimental high energy neutron resonance and low energy spectrometric data, it is possible to fit

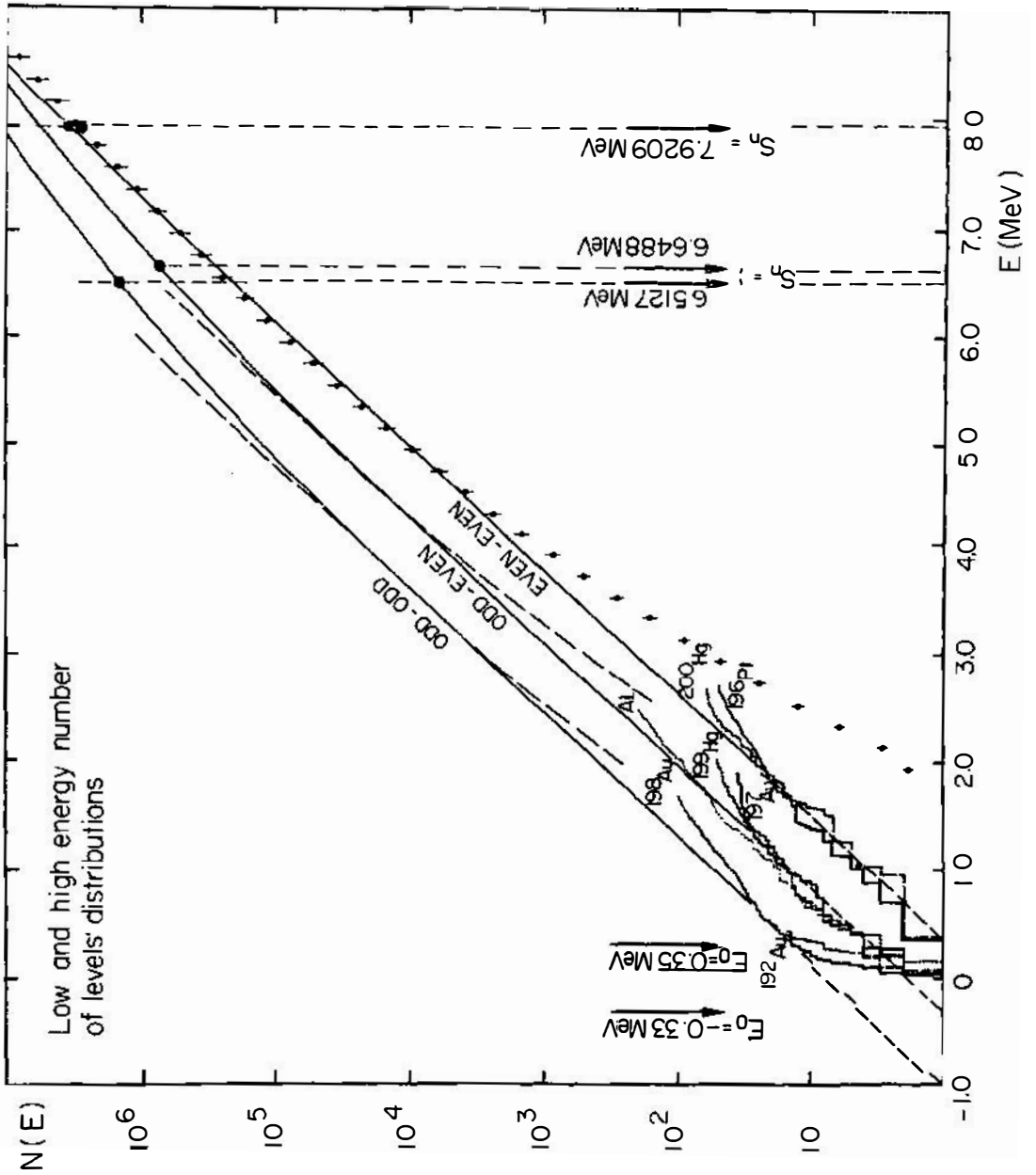


Fig.2. Experimental number of the low energy level distributions fitting the Gilbert-Cameron statistical ("high energy") distributions.

the low (Ericson's) and high (Gilbert-Cameron) distributions of levels for a few even-even, even-odd and odd-odd Hg, Au and Pt nuclei. From the analysis of these distributions (see fig. 2), the following conclusions can be drawn:

1) the lowest part of the  $^{196}\text{Pt}$  and  $^{200}\text{Hg}$  step functions are very near the straight line fitting the  $^{196}\text{Pt}$  Gilbert-Cameron distribution (represented by dots with their experimental errors).

2) The  $^{197}\text{Au}$  distribution of the Alaga model is in good agreement with the low energy distribution fitting the odd-even Gilbert-Cameron one. This is a clear indication of the degree of completeness achieved in the description of the heavy odd mass gold (positive and negative parity) levels with this model.

3) All the  $^{198}\text{Au}$  levels are populated by radiative neutron capture. The difference in slope between the low energy experimental distribution and the straight line fitting the Gilbert-Cameron distribution is due to the missing spin statistical correction in the former distribution.

### III. CONCLUSIONS

This work shows that Ericson's method of nuclear level statistical analysis is a valuable tool for detecting systematic insufficiencies of experimental data as well as for testing the overall descriptions of a nucleus given by different nuclear models.

We are indebted to Professor G. Alaga and Dr. V. Paar for their interest and great help in the theoretical interpretation of the gold nuclear levels. Furthermore, we sincerely thank R. Foucher and his co-workers, V. Berg and C. Bourgeois for communicating  $^{181,189,191}\text{Au}$

level schemes prior to publication and allowing us to deduce from their data the corresponding number of level distributions.

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