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Франк В. и др. E7 - 12203

Об осцилляциях интенсивности в спектрах квазимолекулярного КХ-излучения

Исследовалась тонкая структура сплошных спектров квазимолекулярного КХ-излучения при столкновениях Ni + 39 МэВ Ni. При этом не было обнаружено никаких периодических структур, о появлении которых сообщили авторы других работ.

Работа выполнена в Лаборатории ядерных реакций ОИЯИ.

Сообщение Объединенного института ядерных исследований. Дубна 1979

Frank W. et al. E7 - 12203

On the Intensity Oscillations in Quasimolecular KX-Ray Spectra

The fine structure of continuous quasi-molecular KX-ray spectra in Ni+39 MeV Ni collisions has been investigated. No periodic structure reported by other authors has been observed.

The investigation has been performed at the Laboratory of Nuclear Reactions, JINR.

Communication of the Joint Institute for Nuclear Research. Dubna 1979

1. INTRODUCTION

Investigations of the anisotropy of quasi-molecular KX-ray spectra performed by Wölfli et al.[1-4] revealed a weak periodic structure superimposed on the continuous molecular orbital (MO) radiation. The amplitude of the oscillations observed in the symmetric Ca+Ca, Fe+Fe and Ni+Ni collisions was strongly dependent on the X-ray emission angle with respect to the beam axis, being more pronounced in the spectra taken at 90° than at 30°. The period length of the oscillations observed by Wölfli et al. was scaling like $v \cdot Z$, where v is the projectile velocity and Z the charge of the separated atom. This period was equal to approximately 2 keV for the 40 MeV Ni+Ni collision. The discovered structure appeared in the neighbourhood of the K-transition energy of the united atom and extended far beyond this limit. The discovery of oscillations inspired a number of theoretical investigations explaining this phenomenon as a consequence of dynamic effects in heavy ion collisions. In particular, the following interpretations have been proposed:

(i) interference between the incoming and outgoing ion trajectories[5,6];

(ii) sudden rearrangement of atomic into molecular electron wave functions at a certain critical distance between the colliding ions [5]; and

(iii) rotational splitting of molecular states in a rotating two-centre potential[4,7].

In order to reinvestigate the fine structure of the KX-ray MO spectra, we have performed a series of experiments with the Ni+Ni collisions at various X-ray emission angles.

2. EXPERIMENTAL METHOD AND DATA ANALYSIS

The experiments were performed on a 39 MeV ^{58}Ni ion beam of the U-300 heavy ion cyclotron of the JINR Laboratory of Nuclear Reactions. The experimental arrangement has been described elsewhere /8/. The X-ray spectra were measured with a 25 $mm^2 \times 5$ mm intrinsic Ge spectrometer with an energy resolution of 250 eV at 14 keV. A number of X-ray spectra were registered at angles of 90°, 67°, 45°, 33° and 0° with respect to the beam direction. The measurements were carried out with a target made of natural nickel 0.56 mg/cm^2 thick, placed at an angle of 45° with respect to the beam axis. The pile-up effect was diminished by using an anti-pile-up electronic unit and by absorption of intense Ni K-lines in the 1 mm walls of an aluminium scattering chamber. The number of counts in various spectra at 30 keV X-ray energy ranged from 7000 to 40000 per 1 keV energy interval. Figure 1 demonstrates one of the spectra obtained at an angle of 90°. The evaluated X-ray anisotropy is plotted in fig.2.

From the obtained single spectra the mean, exponentially decreasing smooth component was subtracted and the residue was analysed in the frequency domain using the Fast-Fourier-Transform technique /9/. In order to check the sensitivity of the method, an artificially generated sine function with a period of 2.5 keV added to randomly distributed numbers with a dispersion twice as large as the amplitude of the sine function, has been analysed. As is shown in fig.3, the period of the sine function is well retrieved from the Fourier transform.

After the subtraction of the smooth part of the spectra the squares of the Fourier transforms $F^*(\omega) \cdot F(\omega)$ of the experimental X-ray single spectra in the energy interval from 20 to 50 keV are shown in fig.4.

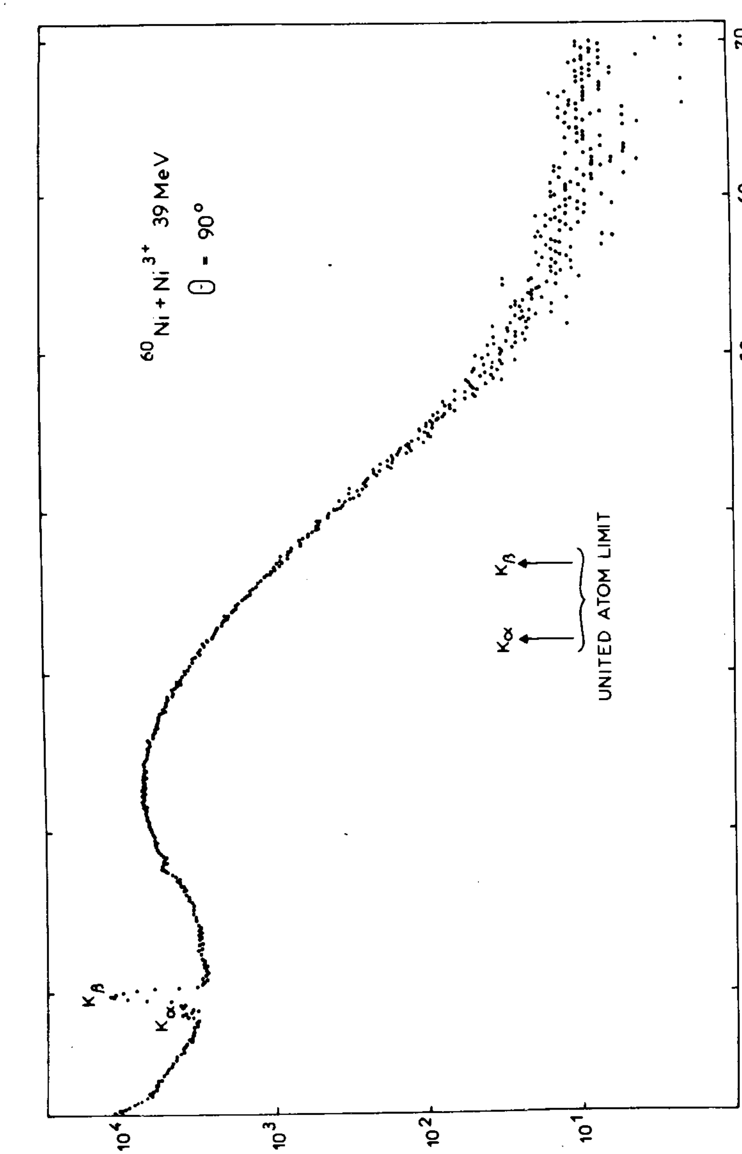

Fig.1. The X-ray spectrum measured in bombardment of a Ni target with 39 MeV Ni ions.

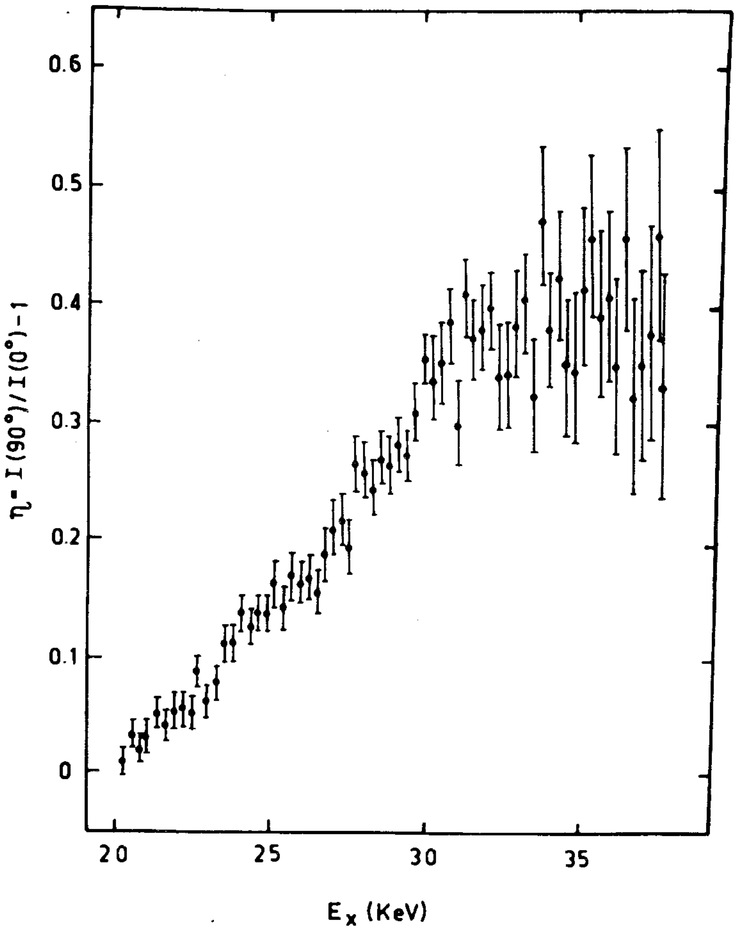

Fig.2. The asymmetry $\eta = I(90°)/I(0°) - 1$ of the quasi-molecular KX-radiation obtained in the Ni+39 MeV Ni collisions.

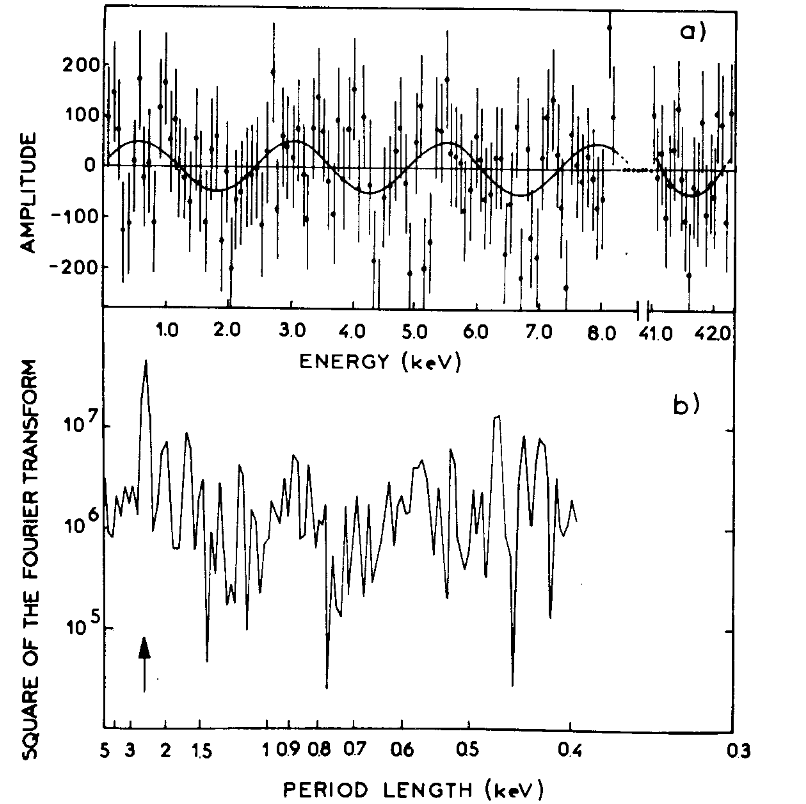

Fig.3.a)The sine function with a period of 2.5 keV added to a random noise with a dispersion twice as large as the sine function amplitude, and b) the square of the Fourier transform of the function shown in (a).

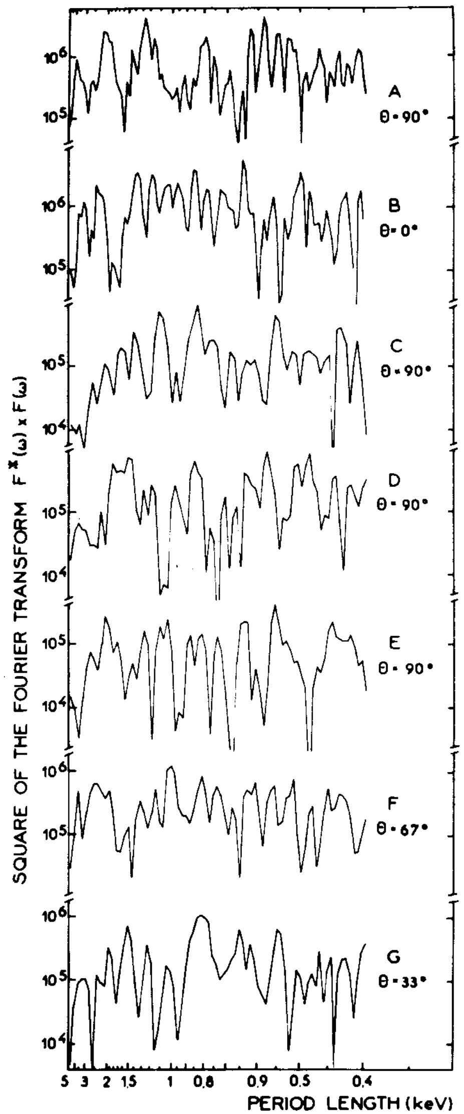

Fig.4. The squares of the Fourier transforms of the experimental X-ray single spectra. For explanations see the text.

3.DISCUSSION

In contrast to the results reported in refs. /1-4/ no strong peaks with a frequency around 2 keV in the Fourier transforms have been observed in the present work. There is no distinct difference either in the Fourier transforms of the spectra taken at 90° with respect to the beam axis and in those taken at 33° or 0°. The lack of correlation between the small frequency peaks in the Fourier transforms of the spectra obtained under the similar experimental conditions suggests their statistical nature. No distinct oscillation could be observed in the anisotropy curve either (fig.2). Therefore, if the fine structure of the KX-ray continuous spectra exists, it could not be observed in the present work with as large an amplitude as that reported in refs. /1-4/. The amplitude of any oscillations with a constant period in the analysed region of the spectra observed in the present work should be much smaller than the statistical errors.

The results obtained in the present paper are consistent with those of refs. /10,11/. It should, however, be noted that the method used in the present work is insensitive to nonperiodical oscillations.

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