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Compton scattering polarimeter "PENGUIN" for solar flares polarimetry

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Abstract. Compton scattering polarimeter is discussed. This instrument will be used for linear polarization measurements of solar flares in energy range from 20keV to 150keV. Scattering detector consists of a number of p-terphenil crystals with total square 120cm^2 and thickness 3cm. The detectors of scattered radiation are CsJ(Na)-based crystals. All detectors are enclosed anticoincidence shields in order to avoid charge particle background. The estimations of efficiency are made by means of Monte-Carlo simulation. Proposed accuracy of polarization measurements is near 10±1%. The stabilization system is used to keep threshold levels not more 1%.

1 Introduction

The scientific motivation for X-ray space polarimetry is well known (Novick, 1975), but the number of real experiments in this field of research is not large until nowadays. Different kinds of instrument may be used for these purposes. Essential solar X-ray polarization has been measured on the Intercosmos satellites (Tindo et. al., 1972). However, for energy range from 20keV to 150keV such kind of instrument is not applied. Compton scattering polarimeter is proposed to be used. This polarimeter is a part of instrument for "CORONAS-PHOTON" mission with the aim of research of solar flares and solar activity. During this experiment the following scientific problems will be solved:

- The measurements of linear polarization of hard X-ray 20keV -- 150keV from Solar flares;
- The observation of energy spectrum of neutron flux with neutron energies from 1MeV up to 50 MeV;
- The research of X-ray and gamma-ray spectra in energy band from 15keV to 5MeV;
- The registration of soft X-ray spectrum in energy band from 2keV to 30keV.

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2 Instrument detectors

The parameter of linear polarization and positional angle may be measured for hard X-ray radiation by means of measuring of Compton scattering asymmetry, if incident flow is polarized. For these purposes the instrument consist of a number of detectors from p-terphenil (PT-detectors). In these detectors the recoil electrons are detected. There are a number of CsJ(Na)-based detectors of scattering radiation. For a detection of Compton scattering radiation the coincidence method is used. Such kinds of detectors give a possibility to solve simultaneously two scientific problems both polarization measurements and neutron intensity ones. For neutron signals the pulse form discriminator circuit is used. CsJ(Na) detectors may be used for research of gamma-ray spectrum up to energy 5MeV. The proportional counters are used for soft X-ray spectrum research.

3 Characteristics of the instrument

The thresholds of gamma-ray registration in pt-detectors are tested. The results of testing show that these thresholds are not more then 1.5keV. But a threshold of gamma-ray scattering radiation in CsJ(Na) crystals is not more then 20keV. It was found that if to use of stilbene crystals as a scattering units then the threshold of neutron detection is not more then 1 MeV, but the coefficient of rejection of gamma-ray events in neutron channel is not less then 1000 in all energy range. However, in this case the threshold of gamma-ray detection increases two times. The satellite experiment conditions require the reliable methods in order to reject a background from charge particles. The long time exposition during such kinds of experiments requires the high level of stability of device parameters. In order to solve these problems, the anticoincidence shields are used. In addition there is a special electronic system of PMT stabilization. The efficiency of charge particle registration is tested on the level of 0.999. Stabilization system compares the signals from different detectors with the electronic circuit signal and keeps the signals from different photo multiplies tubes (PMT) on

required level. Such kinds of stabilization systems were already used in different instruments and the level of stability near 1% was obtained.

4 Monte-Carlo simulation of the efficiency

In order to estimate the efficiency of the polarimeter the Monte-Carlo simulation is made. The model of device consists of a number of scattering p-terphenil based detectors as a cylinder with diameter 4cm enclosed by ring detectors divided by six sectors. Enter diameter of ring is 10 cm. The thickness of pt-detectors is 3cm. The ring of CsJ(Na) detector is used as a detector of scattering radiation. This detector is divided by some sectors too. The thickness of ring is 1.3cm. The vertical size of CsJ(Na) detector is 9cm. This model of device is shown in Fig.1.

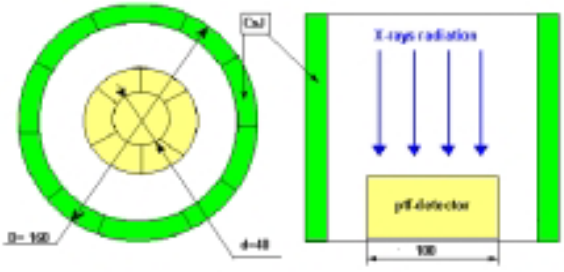

Fig.1: The model of the polarimeter used for Monte-Carlo simulations

During of simulation the processes of coherent scattering, Compton scattering and photo-effect are taken into account. The row level of threshold was tested in pt-detectors (from 1keV to 20keV). The results of simulation are shown in Fig.2.

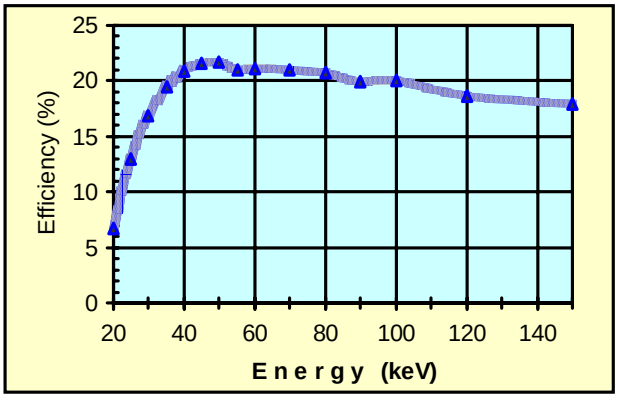

Fig.2: The results of simulation for efficiency of device

5 Conclusion

The application of such kind of polarimeter in energy range from 30keV to 150keV will be a test of theoretical models of Solar flares since this energy range is matched by boundary between of diffusion emission model and the bremsstrahlung model (Henoux, 1975). The efficiency of proposed polarimeter is not worse then this parameter of solar X-ray spectrometer (Yoshimori et al., 1991). The obtained data will be unique in solar flares polarimetry.

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