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Solar flares temporal profiles thin structure on timescales 33-92 sec in various energy bands by data of AVS-F apparatus onboard CORONAS-F satellite

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Abstract: The temporal profiles and energy spectra of the several solar flares observed by AVS-f apparatus onboard CORONAS-F satellite are discussed. The energy spectra of these solar flares contain nuclear lines, positron line and neutrons capture line. Thin structure with characteristic timescales 33-92 sec is presented on flares temporal profiles in energy bands corresponding observed spectral features which confirmed by periodogram analysis (confidence level is 99%). Thin structure on the same timescales was detected earlier by RHESSI in energy band 3-25 keV.

AVS-F apparatus description

The AVS-F (amplitude-time Sun spectrometry) apparatus [1, 2] was installed onboard CORONAS-F satellite (NORAD catalog number 26873, International Designator 2001-032A) which operated from July 31 2001 to December 6 2005. The orbit of satellite was approximately circular oriented towards the Sun with inclination 82.5° and altitude ~500 km. The AVS-F apparatus use signals produced by the SONG-D detector (energy deposition ranges of 0.1-11.0 MeV and 4.0-94.0 MeV by first time calibration data), anticoincidence signal generated by the plastic scintillation counter of the SONG-D and signal from XXS-1 detector, which is the CdTe based semiconductor detector with energy deposition range 3-30 keV. The SONG-D is CsI(Tl)-based detector ∅20cm and height of 10 cm with electronics unit SONG-E [3]. The system energy resolution is 13.0% for γ-quanta with E_γ=0.662 MeV (^{137}Cs). The energy bands limits are shifted during apparatus operation: the energy threshold and amplification coefficient of low-energy band were changed on 1% and 1.8% per month and on January 2005 the low-energy band boundaries were approximately 0.1-20 MeV [4].
Because of high inclination of CORONAS-F satellite orbit the approximation of the background was made by polynomials with power 5 or 4 on the equatorial regions of satellite orbit and with linear function or by constant on polar ones. The integration time for all presented temporal profiles (excluding some ones which are separately mentioned) is 16 s for 0.1-20 MeV energy band [1, 2].

The characteristics of solar flares observed during January 2005 by AVS-F apparatus

During January 2005, 20 solar flares with class M and X were registered on the Sun by detectors onboard satellites GOES, RHESSI, SOHO, TRACE and others instruments. Four active regions 10715, 10718, 10719 and 10720 were sources of these solar flares. Six of them (January 9, January 15, January 17, January 20, and two flares on January 19) were observed in low energy γ-band by AVS-F too [2]. Active region NOAA 10719 was the source of solar flare January 9, the source of other 5 flares was NOAA 10720 one [5]. January 19 flares (M6.7 and X1.3) and solar flare January 9 (M2.4) observed in polar cap regions of CORONAS-F orbit but satellite enter radiation belts during these flares registration. Flare January 20 (X7.1, 06:36-07:26 UT on GOES data) was the most powerful of observed ones. It was accompanied by particles events (protons and neutrons which were most intensive ones for period of the last 15 years [4] and CME. Gamma emission of this flare was observed by AVS-F in both energy

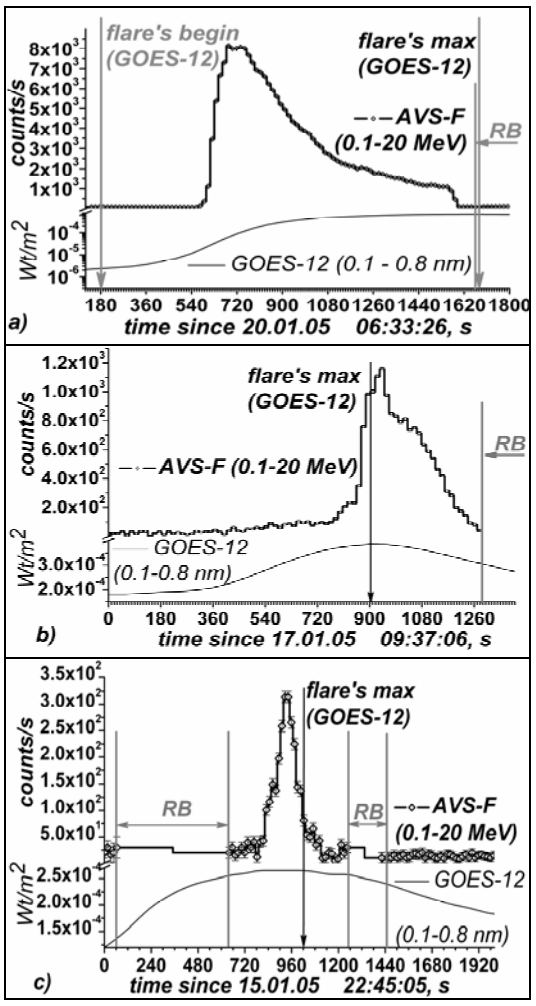

Figure 1: Solar flares January 20 2005 (a), January 17 2005 (b) and January 15 2005 (c) temporal profiles by AVS-F apparatus data in low energy gamma-ray band with background subtraction and by GOES-12 data in 0.1-0.8A region.

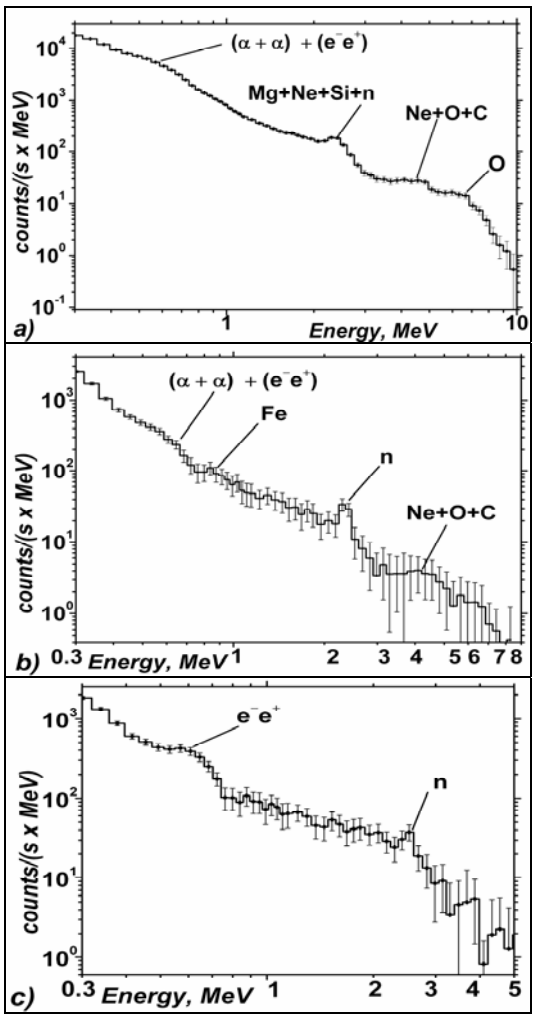

Figure 2: The integrated energy spectra (with background subtraction) of solar flares observed in January 2005: a) January 20 (06:43:16–06:59:51 UT), b) January 17 (09:51:13 - 09:58:40 UT), c) January 15 2005 (22:56:31 - 23:05:51 UT).

bands during X-ray emission rise (before their maximum) by GOES data in equatorial part of CORONAS-F orbit before Radiation belt (Figure 1a). Its temporal profile in high-energy γ-band discussed in [6], but there were not any statistical significant count rate exceeds background level in the high energy γ-band by AVS-F data during January 17 and 15 solar flares. January 17 flare (X3.8, 06:59-07:26 UT by GOES data) was observed by CORONAS-F orbit before Radiation belt (Figure 1a). Its temporal profile in high-energy γ-band discussed in [6], but there were not any statistical significant count rate exceeds background level in the high energy γ-band by AVS-F data during January 17 and 15 solar flares. January 17 flare (X3.8, 06:59-07:26 UT by GOES data) was observed by AVS-F apparatus in equatorial region of satellite orbit too during X-ray emission (by GOES data) maximum and droop (Figure 2b). January 15 flare (X2.6, 22:35-23:31 UT by GOES data) registered by AVS-F on the polar cup region of CORONAS-F

satellite orbit during maximum of X-ray emission (by GOES data) – see Figure 1c. January 20, 17 and 15 flare's integrated temporal profiles shape in low-energy γ-band and X-ray band is very simple with one maximum.

There are four spectral lines complexes in integral spectra of January 20 and 17 flares and two in January 15 one (see Figure 2 and Table 1). All spectral features were observed during whole duration of γ-emission registered by AVS-F.

Table 1: Spectral features of discussed solar flares.

Date	Spectral features and their energy band, MeV
20	αα + e^+e^- (0.4-0.6), $^{24}Mg+^{20}Ne+^{28}Si$ + neutron capture (1.7–2.3), $^{20}Ne+^{16}O+^{12}C$ (3.2-5.0), ^{16}O (5.3-6.9)
17	αα + e^+e^- (0.4-0.6), ^{56}Fe (0.7–0.9), neutron capture (1.7–2.3), ^{12}C (3.6-5.0)
15	e^+e^- (0.5-0.6), neutron capture (2.0–2.3)

January 2005 20, 17 and 15 temporal profiles thin structure

Temporal profiles by AVS-F apparatus data in energy bands corresponding spectral features discussed in previous section for solar flares January 20 2005, January 17 2005 and January 15 2005 are shown at Figure 3. There are two maxima at solar flare January 20 temporal profile in energy band 0.4 – 0.6 MeV at 06:44:36 and 06:53:46 UT which correspond to maxima in range 0.1 – 0.3 MeV in

Table 2: Characteristic timescales of solar flares discussed.

Flare date	Energy band, MeV	Characteristic timescales, s					
20	0.4-0.6	83	64	49	44	38	33
	1.7-2.3	69	52	44	40	35	–
	3.2-5.0	92	46	42	36	–	–
	5.3-6.9	92	59	44	38	–	–
17	0.4-0.6	61	37	–	–	–	–
	0.7-0.9	61	46	33	–	–	–
	1.7-2.3	61	46	33	–	–	–
	3.2-5.0	64	35	–	–	–	–
15	0.4-0.6	61	47	41	34	–	–
	2.0-2.3	87	34	–	–	–	–

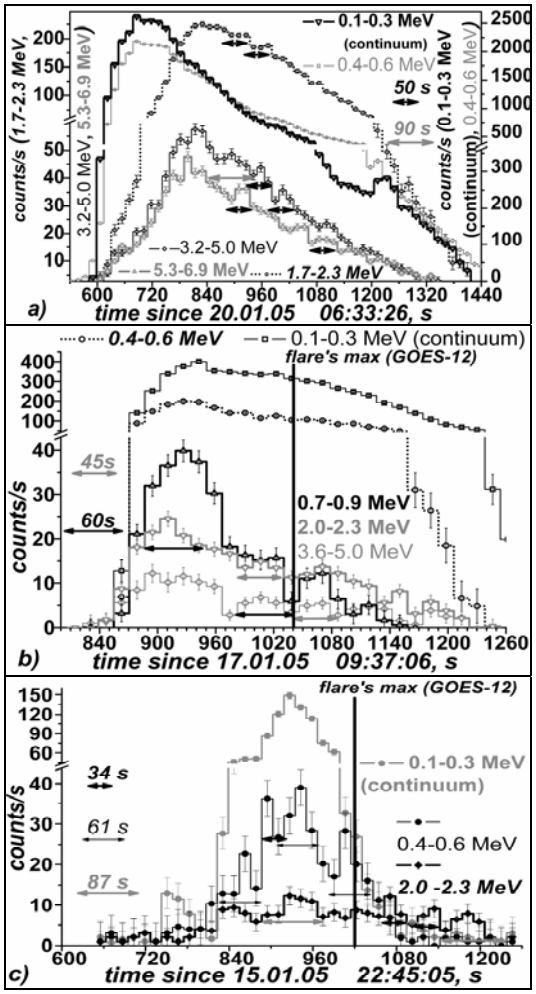

Figure 3: Solar flares January 20 2005 (a), January 17 2005 (b) and January 15 2005 (c) temporal profiles by AVS-F apparatus data in energy bands corresponding spectral features at Figure 2 and their characteristics timescales.

statistical errors limits. One maximum at 06:46:36 UT was in energy bands 3.2 – 5.0 MeV and 5.3 – 6.9 MeV and one maximum at 06:47:16 UT was observed in range 1.7 – 2.3 MeV. Following main maxima are separated on January 17 flare temporal profiles: 09:41:26 UT (0.15 – 0.30 MeV), 09:40:36 UT (0.4 – 0.7 MeV), 09:42:31 UT (0.7–0.9 MeV), 09:42:16 UT (2.0–2.3 MeV) and 09:41:54 UT (3.6–5.0 MeV). Temporal profiles of January 15 solar flare had one maximum in each studying energy band: at 23:00:19 UT in corresponding continuum

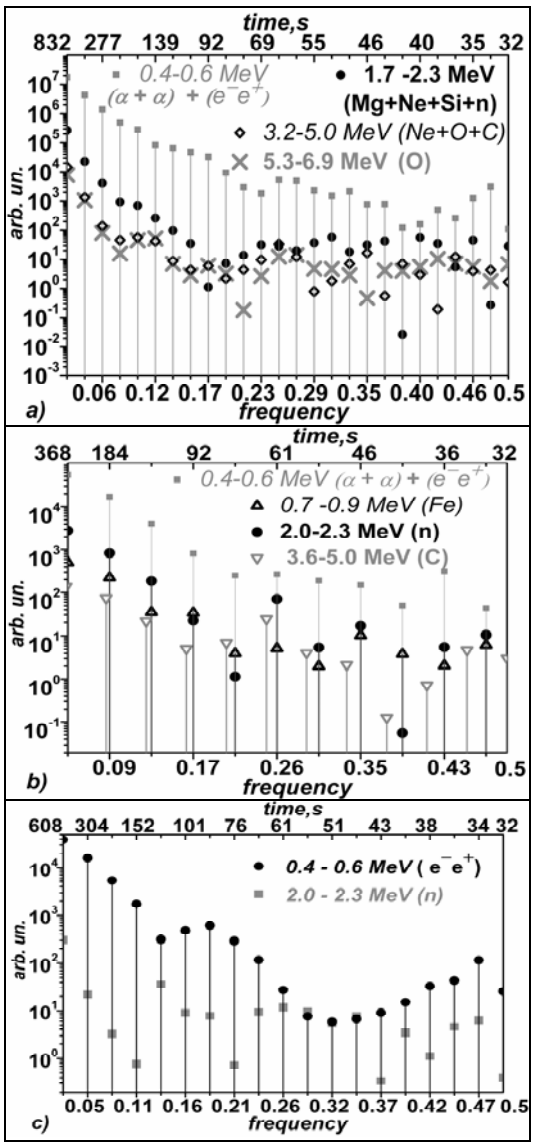

Figure 4: Periodograms for shown at Figure 3 solar flare temporal profiles: January 20 2005 (a), January 17 2005 (b) and January 15 2005 (c).

range and at 23:00:45 UT in 0.4–0.6 MeV and 2.0–2.3 MeV ones. Discussed flares were sufficiently long for studying thin structure at timescales of some tens seconds. Corresponding periodogram are shown at Figure 4. Thin structure is presented at temporal profiles of these three solar flares. Characteristics timescales are in range 33 – 92 s for January 20 solar flare, 33 – 61 s for January 17 and 34 – 87 s for January 15 ones at 99% significance level – see Figure 3 and Table 2. Thin structure on the same timescales was detected earlier by RHESSI in energy bands 3-25 keV for January 20 solar flare.

Conclusions

The wide range temporal profiles of January 20, 17 and 15 2005 solar flares time structure by AVS-F data is very simple with one maximum. But temporal profiles structure is more complex in energy bands corresponding nuclear lines, positron line and neutrons capture line observed in these flare energy spectra. There are two maxima at solar flare January 20 temporal profile in energy band 0.4 – 0.6 MeV which correspond to maxima in range 0.1 – 0.3 MeV. In other energy bands one main maximum was observed on all discussed solar flares temporal profiles but thin structure with characteristic timescales 33-92 sec is presented on them in energy bands corresponding observed spectral features exclude 0.1-0.3 range (continuum). Periodogram analysis confirmed existence of such structure (confidence level is 99%).

References

[1] A.I. Arkhangelsky, A.S. Glyanenko, Yu.D. Kotov. Instruments and Experimental Techniques, 42, #5, 596, 1999.

[2] I.V. Arkhangelskaja, A.I. Arkhangelsky, Yu.D. Kotov, S.N. Kuznetsov, A.S. Glyanenko. Solar System Research, 40, 133, 2006.

[3] S.N. Kuznetsov, A.V. Bogomolov, Yu.V. Gordeev, Yu.V. Gotselyuk, Yu.I. Denisov, A.V. Dmitriev, M.A Kovalevskaya, G..V. Lupenko, I.N. Myagkova, M.I. Panasyuk. Rossijskaya Akademiya Nauk, Izvestiya, Seriya Fizicheskaya, 59, #4, 2, 1995.

[4] D.C. Wilkinson and J.H. Allen AGU Spring Meeting Abstracts, A5, #SP23A-05, 2005.

[5] R.W. Nightingale, Z.A. Frank, T.R. Metcalf, C. A. Kang. AGU Spring Meeting Abstracts, A10, #SP21A-10, 2005.

[6] I.V. Arkhangelskaja, A.I. Arkhangelsky, A.S. Glyanenko, Yu.D. Kotov, S.N. Kuznetsov. Proceedings of the 11th European Solar Physics Meeting "The Dynamic Sun: Challenges for Theory and Observations", (ESA SP-600). 11-16 September 2005, Leuven, Belgium. Editors: D. Danesy, S. Poedts, A. De Groof and J. Andries, P.107.1, 2005.