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ORIGIN OF DELAYED EVENTS

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Abstract. In order to investigate the origin of delayed events we compare experimental spectra with theoretical spectra, derived under different assumptions about the net energy change in the source, during acceleration. The analysis is performed for both, a velocity dependent and a velocity independent acceleration stage. From this first approach it is not possible to designate a definite origin to each one of the different kind of delayed events (ESP, LESP, recurrent and corrotating or long lived streams) but it is found that whatever the type of event, the acceleration spectrum is determined either at the sun or in the interplanetary medium or even by the superposition of acceleration at both levels. However particles in long lived streams seem to be always preliminarily accelerated at the sun. The most probably acceleration efficiency associated to each event is obtained. Adiabatic cooling during acceleration is more important in the interplanetary space that in the solar atmosphere. Propagation models delineated on basis of time profile analysis most be complemented by acceleration models based on energy spectra analysis in order to build a consistent theory.

1.-Introduction. Although the classification of solar particle events is quite variable, according to different authors, two main catagories can however be definitively distinguished: those with a rectilinear transit in the next minutes to the associated flare, by means of diffusive propagation, which are called "prompt events" and those which do not present these features and that usually appear after the flare associated event, or even in isolation of a definite solar flare. We shall denominate the later as "delayed events";though this does not agree with previous definitions (e.g. Anderson 1969,a,b;McCracken and Rao 1970,McDonald and Desai 1971;Wibberenz 1971) however it is enough within the scope of this work, in the sense that all of them do not behave as prompt events. Therefore, we shall study in this categorie (a) The energetic storm particles (ESP)(e.g. Bryant et al.1962;Axford and Reid 1963;Rao et al.1967;Van Allen and Ness 1967;Lanzerotti 1969,1964, etc.) with their different varings (Core and Halo events, Lin et al. 1968)(b)LESP (spike-like) events (e.g. Palmeira et al.1971;Singer and Montgomery 1971;Sarris and Van Allen 1974;Gloeckler et al.1974;Sarris et al.1976,etc.)(c) Recurrent events (e.g. Bryant et al.1963, 1965a; Fan et al.1965;Lanzerotti 1969;McDonald and Desai 1971,etc.)(d)Long lived streams or corrotating events (Fan et al. 1968;Bryant et al. 1965b;Krimigis 1969;Fan et al.1965;Kinsey 1970, etc.). Concerning the origin of delayed events there is at present a great controversy around whether particles are generated at the sun-level, in the interplanetary space, or in a superposition of both effects. A great variey of models for explaining the acceleration and transport processes of these different events have been developed (see for instance reviews of Datlowe 1972; McCracken and Rao 1970;Anderson 1969a;Wibberenz 1976;Roelof and Krimigis 1975, and references therein). Models supporting solar production propose an acceleration process relatively slow with respect to that of prompt events, as for instance, continual acceleration,in high flaring regions,or a slower propagation process in the solar atmosphere, acceleration in the back side of the sun, storage of prompt accelerated particles with gradual leackage, etc. On the other hand since all of these different events are usually accompanied by Forbush effects,SC, and appear associated to interplanetary disturbances (shock waves,tangential discontinuities, solar wind irregularities), a great amount of proposal for interplanetary origin have been given. However several objections have been extended against these two main currents:for instance the lack of systematic continuous emissions of type III,IV and X rays in the cases of continual acceleration or coronal storage. In the case of interplanetary production it is opposed the fact of a fast shock waves pasage in contrast with the relatively long duration of some events, as well as the arrival time differences between electrons and protons, etc. Some objections seem to be overtaken and new models are continuously developed, but there is not yet a general assent about delayed events origin. Which seems common to most of the different models is that they are built from the study of solar particle propagation through the analysis of their time profile;but evidently the complexity of the delayed events origin is determined by not only the propagation process but by the acceleration process, either at one or at different levels. Therefore instead of studying the event time profile, we shall analyse the energy spectrum of particles, that although in general covers a short time interval and it is undoubtedly modulated during propagation, however a very fruitful information may be obtained about the acceleration region location,the energy change processes during acceleration,the physical conditions at the source,etc. The several kinds of questions which are associated with the problem of delayed events origin are for example,whether there is a continual acceleration at the sun, particle diffusion in solar longitude or particle storage,whether the acceleration and propagation process are velocity dependent or not, whether there is sweeping or acceleration in association with the interplanetary shocks,whether acceleration occurs behind or ahead a shock,whether the acceleration process may be assimilated to a 1st order Fermi-type or a 2nd order Fermi-type and whether convection and adiabatic deceleration play an important role on solar particles. We do not claim, of course, to investigate these several features through this work but only to draw preliminar inferences about the plausible location of the particle acceleration region and energy change processes during acceleration. Obviously it is not our purpose to delineate a model, but simply to search for the adequated direction to build future models or to discriminate between the existing proposals. Therefore in order to do so, we shall derive theoretical expressions for the acceleration spectrum of solar particles, under different assumptions on the net energy change rate during acceleration;for comparing them with experimental spectra of some delayed events. We are thus assuming that adiabatic deceleration after acceleration acts only in depressing the acceleration spectrum as well as the possible effects acting during propagation do not mask completely the source effects.

2. Energy change rate and acceleration spectrum. Since the acceleration period may probably be enough long and the acceleration region probably quite extended, several processes can be affecting particles during their acceleration, such as catastrophic changes of particle density from the accelerated flux or energy losses. However assuming that the mean free path for nuclear interactions is larger than the acceleration region dimensions, we can neglect nuclear transformations and energy losses from p-p collisions. Therefore, together with the plausible energy loss processes during acceleration we shall also consider particle losses by escape from the acceleration region under two different assumptions: either the escape time $\tau \sim 1/\beta$ (with β the particle velocity in terms of the light velocity) or τ=constant and taken for simplicity as the unit (this value is not so far from those obtained in connection with the problem of heavy nuclei overabundance of prompt events, Pérez-Peraza et al. 1977). The first assumption of the velocity dependence in the acceleration rate is not entirely arbitrary, since we try in this way to interpret some observational results (Bryant et al. 1965b). Concerning energy losses we shall assume that particles may suffer ionization losses and eventually adiabatic deceleration at the sun level, and only adiabatic cooling in the interplanetary medium. In the later case adiabatic cooling may occur while particles are accelerated in a 2nd order process by random irregularities of a solar expanding plasma behind a shock, or ahead a shock (by a 1st or 2nd order Fermi type mechanism, e.g. Wentzel 1962,Schatzman 1963) which is overtaking and expanding plasma. In fact adiabatic cooling does not affect very strongly protons of E>300 KeV, since according to Wentzel (1973)it is supposed that adiabatic cooling becomes negligible as the particle velocity V satisfies the following criterion ($V \gg v_g + v_A$) where v_g and v_A are the gas and Alfvén velocities respectively. This is the case in the interplanetary medium even for an interplanetary disturbance of 3000 Km s^{-1}. At any event as it can be seen from the results displayed in section 3, the acceleration rate is systematically higher than the adiabatic cooling rate either in the velocity independent case, Eq. (5), ($a/\rho\beta^2$), or in the velocity dependent case, Eq.(6),($a/\rho\beta$). This is true even for the extreme assumption of $\rho = 4/3(v/R) \simeq 10^{-3}$ (which seems relatively high for the interplanetary case), where v and R are the expansion velocity and expanded distance respectively. Let us now establish the energy change rate under the different assumptions mentioned: We assume, first, that adiabatic cooling or heating is related to the large-scale expansion or compression of the solar wind plasma,whereas the basic acceleration process is associated with the small-scale random features of the solar and interplanetary fields,which undoubtedly exist in turbulent regions. Adiabatic heating is included as an indicator of the occurrence of a 1st order Fermi type process either between two opposite shocks or a shock pair (a shock overtaking a first one) or between an approaching disturbance to a tangential discontinuity, to a boundary sector or to a bow shock, etc. We do not pretend to draw conclusions about the acceleration process in this preliminary work,but only to determine whether a systematic acceleration is increasing the energy of particles by the action of two magnetic walls with a relative velocity of approach between them. Therefore as we shall see later, the adiabatic heating rate has been underestimated as a measure of reliance that approaching magnetic structures have been present. Since the fundamental acceleration is assumed to be of the 2nd order Fermi type,the acceleration rate is taken energy dependent $dE/dt = (a/\tau)W$ (see for instance Wentzel 1965) which is consistent with some recent observational results (Amstrong and Krimigis 1976) (where a and W are the acceleration efficiency and the total energy of particles respectively). Therefore if the relatively slow acceleration process in delayed events occurs in the interplanetary space by a 2nd order Fermi type mechanism, in absence of noticeable adiabatic expansion or compression, the energy change in both the velocity independent and dependent cases are:

$$(d\gamma/dt) = a\gamma \tag{1}$$

and

$$(d\gamma/dt) = a(\gamma^2 - 1)^{1/2} \tag{2}$$

where γ is the Lorentz factor. Similarity if acceleration is performed at the solar atmosphere in absence of adiabatic expansion or compression the net energy change rates are:

$$(d\gamma/dt) = a\gamma - (b/mc^2)\gamma(\gamma^2-1)^{-1/2} \tag{3}$$

and

$$(d\gamma/dt) = a(\gamma^2-1)^{1/2} - (b/mc^2)\gamma[\gamma^2-1]^{-1/2} \tag{4}$$

where mc^2 is the proton rest mass, $b \simeq 2\times10^{-7}n$(MeV s^{-1}) and n is the medium concentration. The critical threshold value for effective acceleration is given by $\gamma_c = (b/2amc^2)+1$ and $\gamma_c = [b^2(mc^2)^2+a^2]^{1/2}/a$ in Eqs. (3) and (4) respectively. When particles are accelerated simultaneoulsy with adiabatic heating or adiabatic cooling in the interplanetary space, rates (1) and (2) become

$$(d\gamma/dt) = a\gamma \mp \rho(\gamma^2-1)\gamma^{-1} \qquad (5)$$

and

$$(d\gamma/dt) = a(\gamma^2-1)^{1/2} \mp \rho(\gamma^2-1)\gamma^{-1} \qquad (6)$$

where the value of ρ is expected to be higher for adiabatic heating (sign plus) than for adiabatic deceleration (sign minus). In the case of adiabatic cooling the threshold value for effective acceleration when $a<\rho$ are $\gamma_c=(1-a/\rho)^{-1/2}$ and $\gamma_c = (1-(a/\rho)^2)^{-1/2}$, in Eqs. (5) and (6) respectively, and $\gamma_c = 1$ when $a \geqslant \rho$. When acceleration at the solar atmosphere is carried out while adiabatic deceleration, the energy change rate (3) and (4) are transformed in

$$(d\gamma/dt) = a\gamma-(b/mc^2)\gamma(\gamma^2-1)^{-1/2}-\rho(\gamma^2-1)\gamma^{-1} \qquad (7)$$

and

$$(d\gamma/dt) = a(\gamma^2-1)^{1/2}-(b/mc^2)\gamma(\gamma^2-1)^{-1/2} - \rho(\gamma^2-1)\gamma^{-1} \qquad (8)$$

The critical threshold values for effective acceleration are obtained from two different 6th degree equations which solution shows that ionization and adiabatic losses behave inversely while getting away from the sun. Now in order to establish the particle spectrum in the acceleration region, we want to point out that it is difficult to accept steady state conditions in the solar atmosphere during active periods, as well as in the turbulent interplanetary plasma; however provided that the acceleration time is longer than the characteristic value of τ, the integral spectrum obtained in the general and stationary cases are strongly similar (Wentzel 1965;Heristchi et al. 1976). This is the case in solar particle production where the acceleration process in prompt events seems to occur in a time of 10^2-10^3 sec and presumptively much longer in delayed events, whereas τ is obviously lower than the time elapsed, t_m (tabulated in Table 1) to rise particles from the threshold energy value imposed by energy losses, up to the high energy cutoff inherent to each acceleration mechanism. Furthermore, the approximation of the quasi-equilibrium state may also be assumed when other processes are considered,as for instance, in the interplanetary space where the time scale of the expansion (through 1 AU) is longer compared with the characteristic diffusion times (for E>0.3 MeV and mean free path $\geqslant$0.06 AU). Therefore using the formalism of the Fermi Age theory (Fermi,1949) where an analogy between the energy distribution of cosmic rays and radioactive decay is assumed, we obtain a differential spectrum of the form $N(t)dt = N(\gamma)d\gamma = (N_0/mc^2\tau)\exp(-t/\tau)d\gamma$, where t, is the necessary time to accelerate particles up to the energy E and N_0 is the flux entering in the acceleration process. The integral spectrum is then obtained by integrating up to the high energy cutoff E_m of the accelerated protons (Heristchi et al. 1976)

$$J(>\gamma) = \int_{\gamma}^{\gamma_m} N(\gamma)d\gamma = N_0[\exp(-t/\tau)-\exp(-t_m/\tau)] \qquad (9)$$

where t_m is the acceleration time mentioned above. Since acceleration is effectively fixed in particles only beginning at the critical value γ_c,defined by $(d\gamma/dt)= 0$, the acceleration times are defined as

$$t = \int_{\gamma_c}^{\gamma}(d\gamma/dt)dt = t(\gamma)-t(\gamma_c)$$ and hence $t_m = t(\gamma_m)-t(\gamma_c)$. Therefore in the cases of the situations described by Eqs.(1) and (2) when $\gamma_c=1$, the acceleration spectrum is obtained by introducing in (9) the following expressions respectively

$$t = (1/a)\ln|\gamma|;\ t = (1/a)\ln|\gamma+(\gamma^2-1)^{1/2}| \qquad (10)$$

the acceleration spectrum in the situation of Eq. (3) is obtained from the following expression

$$t = \ln\left[|\gamma/\gamma_c|^A \left|\frac{a(\gamma^2-1)^{1/2}-(b/mc^2)}{a(\gamma_c^2-1)^{1/2}-(b/mc^2)}\right|^{c/2}\right] + B(\tan^{-1}(\gamma^2-1)^{1/2}-\tan^{-1}(\gamma_c^2-1)^{1/2}) \qquad (11)$$

where $A=a/(a^2+b^2m^2c^4)$; $B= b/(a^2+b^2m^2c^4)$ and $C= b^2/a^2m^2c^4$; and similarity from (4) we obtain the acceleration time from γ_c to γ as

$$t = \ln\left[\left|\frac{\gamma}{\gamma_c}\right|^{1/a}\left|\frac{\gamma K_1-K_2}{\gamma K_3+K_4}\right|^P\left|\frac{\gamma_c K_3+K_4}{\gamma_c K_1-K_2}\right|^P\right] + \xi\left\{\tan^{-1}\left[\frac{(\gamma-1)K_5}{\gamma+1}\right] - \tan^{-1}\left[\frac{(\gamma_c-1)K_5}{\gamma_c+1}\right]\right\} \qquad (12)$$

where $P= y_3/2(-y_2)^{1/2}\Phi^{1/2}$; $\xi= y_4/(\Phi y_1)^{1/2}$; $K_{1,3}=\Phi^{1/2}\mp(-y_2)^{1/2}$;$K_{2,4}=(-y_2)^{1/2}\pm\Phi^{1/2}$;$K_5=(\Phi/y_1)^{1/2}$ with

$\Phi= b/mc^2$; $y_1= 2a+(4a+\Phi^2)^{1/2}$; $y_2= 2a-(4a^2+\Phi^2)^{1/2}$; $y_3= (2\Phi/a)[(\Phi-y_2)/(y_1-y_2)]$ and $y_4= (2\Phi/a)[(y_1-\Phi)/(y_1-y_2)]$. From Eq. (5) we have in the case of adiabatic deceleration

$$t= \ln|[\gamma^2(a-\rho)+\rho]/[\gamma_c^2(a-\rho)+\rho]|^{1/2(a-\rho)} \qquad (13)$$

and in the case of adiabatic heating

$$t= \ln|[\gamma^2(a+\rho)-\rho]/[\gamma_c^2(a+\rho)-\rho]|^{1/2(a+\rho)} \qquad (14)$$

similarily the acceleration times in Eqs. (6) are

$$t= \ln[|a\gamma-\rho(\gamma^2-1)^{1/2}|^{\chi}|a\gamma_c-\rho(\gamma_c^2-1)^{1/2}|^{-\chi}|[(\gamma^2-1)^{1/2}+1]/[(\gamma^2-1)^{1/2}-1]|^{\psi}|[(\gamma_c^2-1)^{1/2}-1]/[(\gamma_c^2-1)^{1/2}+1]|^{\psi}] \qquad (15)$$

where $\chi = \pm\rho/(a^2-\rho^2)$; $\psi= a/2(a^2-\rho^2)$ and the sign minus and plus denoting adiabatic cooling and heating respectively. Finally in the case of Eqs. (7) and (8) the variable change $Z=\gamma(\gamma^2-1)^{12}$ has been used and integrated by partial fractions. Since the variation range of a,b, and ρ values is very wide, four different spectral shapes are obtained (according to the different combinations of the roots) that for lack of space we do not present here.

3. Results. The intercomparison of theoretical and experimental spectra has been carried out by normalizing both fluxes at the minimum energy for which available experimental data are effectively worthy, and of course with $J(>\gamma_m)\equiv0$. Therefore the adequate acceleration efficiency corresponding to each one of the assumptions (Eqs. (1) to (8) in each event has been determined by the best fit obtained between the corresponding theoretical spectral shape (derived from Eq. (9)) with the experimental curves, in such a way to avoid crossing under them. Once the best representation of each theoretical curve has been determined in each event, we have proceeded to intercompare them under the assumption that the theoretical curve (among the ten possibilities worked out) which nearest approaches the experimental one, in a given event, describes better the kind of phenomena occurring in the acceleration region. In the case of solar production (Eqs. (3),(4),(7) and (8) we have explored in each event the domain $n= 10^7$-10^{13} cm^{-3}, with $\rho\approx10^{-3}$s^{-1} corresponding to v= 550-1100 Km s^{-1} throughout R= 1-2 $R_\odot$. For adiabatic deceleration in the interplanetary space we have taken $\rho= 4\times10^{-6}$ corresponding to v=≈400 Km s^{-1} and R≈ 1 AU, whereas for adiabatic heating we have considered $\rho= 2\times10^{-5}$ corresponding to the relative velocity v_r ≈1500 Km s^{-1} and R≈0.3- 1 AU. We have tabulated in Table 1 the results obtained for the different delayed events, concerning the most probably acceleration efficiency, location of the acceleration region in the solar atmosphere and acceleration time of the highest energy particles (which states a lower limit for the whole acceleration process). However this time may be slightly overestimated in the sense that it represents acceleration interval from γ_c to γ_m, though in fact particles begin to

Table 1.- Solar delayed events: ESP events (1-7), LESP events (8-12), recurrent events (13-20) and Long Lived Streams (21-28). Acceleration times and efficiencies at the sun, were obtained from Eqs. (3) and (4) in the interplanetary space from Eqs. (5) and (6).

		SOLAR ORIGIN				INTERPLANETARY ORIGIN			
Event	Reference	a	t(S)	β=V/C	n(cm^{-3})	a	t(S)	β=V/C	Energy Changes
1 30-IX-61	Bryant et al. 1962	0.067.	25.4	dep.	10^{12}				
2 2-X-61	"					0.028	0.0091	dep.	Adiabatic cooling. 1st order acceleration
3 3-X-61	"					0.022	0.015	dep.	Adiabatic cooling. 2nd order acceleration and ∿ 1st order acceleration.
4 8-VII-66 (core)	Lin et al. 1968	0.0047	2.3	indep.	10^9				
5 8-VII-66 (Halo)	Van Allen & Ness,1967	0.051	35.2	dep.	10^{12}				
6 30-V-67	Singer & Montgomery,1971 Lanzerotti, 1969	0.0026	3.3	indep.	10^{10}	0.0026	3.2	indep.	Adiabatic cooling. 2nd order acceleration
7 20-XI-68	Lanzerotti, 1974	0.039	40.5	dep.	10^9	0.039	.0042	dep.	Adiabatic cooling. 2nd order acceleration
8 30-V-67	Rao et al. 1969 Palmeira et al. 1971	0.026-0.031	<67.4	dep.	10^9	0.026-0.031	0.0072	dep.	Adiabatic cooling. 2nd order acceleration
9 5-VI-67	Singer &Montgomery,1971	0.022-0.032	<83.1	dep.	10^{11}-10^{12}				
10 11-I-68	Singer &Montgomery,1971 Lanzerotti, 1974					0.0073	8.78	indep.	Adiabatic cooling. 2nd order acceleration ∿ 1st order acceleration
11 20-II-68	Singer&Montgomery, 1971	0.019	81.3	dep.	10^9	0.018	7.1	dep.	Adiabatic cooling. 1st order acceleration ∿ 2nd order acceleration.
12 14-V-69	Lanzerotti, 1974	0.069	32.4	dep.	10^{13}				
13 11-II-63	Bryant et al. 1965a					0.0025	5.0	indep.	Adiabatic cooling. 1st order acceleration
14 10-III-63	"	0.044	40.3	dep.	10^{12}	0.003	4.6	indep.	Adiabatic cooling. 2nd order acceleration
15 5-IV-63	"	0.042	48.1	dep.	10^{13}	0.0017	7.5	indep.	Adiabatic cooling. 2nd order acceleration
16 27-V-63	"	0.041	43.4	dep.	10^{11}				
17 2-V-63	"					0.0042	3.2	indep.	Adiabatic cooling. 1st & 2nd order accel.
18 25-VI-63	"	0.046	30.6	dep.	10^{12}	0.0034	4.3	indep.	1st order acceleration
19 2-10-XII-63	Fan et al. 1965	0.036-0.057	<50.2	dep.	10^{12}-10^{13}				
20 18-X-64	"	0.02	81.5	dep.	10^{11}				
21 26-VI-67	Lanzerotti, 1969	0.041	43.7	dep.	10^{12}	0.0015	10.6	indep.	Adiabatic cooling. 2nd order acceleration
22 22-23-VIII-66	Fan et al. 1968	0.023-0.044	<67.5	dep.	10^{10}-10^{13}				
23 27-VIII-66	"	0.05	34.3	dep.	10^{12}				
24 13-17-VI-67	Kinsey, 1970	0.13-0.079	<25.8	dep.	10^{12}-10^{13}				
25 14-21-VI-67	Krimigis, 1969	0.0011	1.92	indep.	10^{10}	0.001	2.12	indep.	1st. order acceleration
26 21-25-VI-67	Kinsey, 1970	0.029-0.069	<58.9	dep.	10^{10}-10^{13}	0.029	0.0084	dep.	Adiabatic cooling. 2nd order acceleration
27 16-XI-67	Allum et al. 1971	0.025-0.03	<62	dep.	10^{10}-10^{11}				
28 17-IX-71	McGuire et al. 1975	0.0093-0.013	<156.2	dep.	10^7 -10^{10}				

be accelerated from the local energies of the solar plasma on the enhanced storm plasma. The velocity behavior of particles within the acceleration region is also indicated in Table 1 for both solar and interplanetary acceleration process. Last column concerns the energy change of particles in the interplanetary medium, that can be inferred on basis to our assumptions in section 2. Indirect inferences will be discussed in the next section.

4. Discussion. According to the results summarized in Table 1, energetic particles in ESP,LESP and recurrent events (1-20) are either of solar or interplanetary origin, or even of a superposition of particles accelerated at both levels; pure interplanetary events seem to be the less common origin whereas the superposition of solar and interplanetary acceleration occurs with more frequency. Long lived stream seems to have been always originated in the sun and in some occasions reaccelerated in the interplanetary medium. At the sun level, adiabatic cooling does not contribute to decelerate particles (Eqs. (7) and (8)). Since 1st order acceleration at the sun level has not been explored in this work, thus, as it was previously discussed, we assume an stochastic acceleration process. For those events of pure solar origin where the acceleration process distributes particles in a velocity-dependent way and observations show no-velocity dispersion, we argue that after acceleration, particles have propagated through the corona with velocity-independent diffusion (Newrkirk and Wentzel 1977); this is the case in recurrent events and long lived streams where the fluxes are most of times velocity-independent (e.g. events 16, 19, 20, 22, 23, 24, 27 and 28). Concerning the acceleration place in association with interplanetary shocks, it may be thought that in those events where 1st order acceleration seems to be predominant, the acceleration has taken place ahead the shock (e.g. events 18, 25 and probably events 2, 11, 13) whereas in those events where adiabatic cooling has taken place together with 2nd order acceleration, probably have happened behind the shock (e.g. events 3, 6, 7, 8,10, 14, 15, 21 and 26). The presence of magnetic disturbances in the interplanetary space, in coincidence with a delayed event of pure solar origin, may be taken as indicator of a plausible sweeping without any noticeable acceleration (e.g. events 5, where a disturbance of 890±60 Km s^{-1} was detected, and probably also event 1, where a disturbance of 1000 km s^{-1} was predicted by Axford and Reid 1963). A very peculiar result obtained in this approach concerns those events where particles have been accelerated at both, the sun and the interplanetary medium : in some cases the same acceleration efficiency at both levels is maintained (events 6,7,8,11,25 and 26), whereas in others the efficiency decreases sharply in the interplanetary space (events 14,15,18 and 21). This may perhaps indicate, in the first case, that the source moves with the coronal plasma enclosing the bulk of particles, in a time lower than $\sim$70 s; in the second case, the sources being different, it can be thought that the acceleration spectrum is practically determined at the sun. Also it is noted that particles distributed by the solar acceleration process in a velocity-dependent way, leave most of times the interplanetary acceleration step with no velocity dispersion, though the opposite situation probably does not occur. This must be explained from inherent features of the interplanetary acceleration, or, as it was mentioned above by propagation through the outer atmosphere. Particles from the halo event of July 8,1966 may have been injected from the core events, and reaccelerated by a different and more efficient process. Superposition of first and second order acceleration effects seems to be evident in some events (e.g. event 17). In order to test the validity of the obtained acceleration efficiencies, for instance from a= (u/c) (with u the accelerating elements velocity) we should know the associated Moreton or blast wave velocities in each event. Therefore we feel that this procedure and most of the conjectures developed in this section must be substantiated in a future work, by a deeper analysis of the associated phenomena in each case. Concluding, we believe that the selection of a particular type of model to describe solar delayed events is a difficult task, since in fact, most of the existing proposals may be applied to a particular event: events of solar origin may be studied for instance from the point of view of several models, such as those of Gold, 1959;Fan et al. 1968;Lin et al. 1968;Anderson 1969a;Simnet et al. 1969, etc. for interplanetary events we have for instance, Axford and Reid 1963;Rao et al. 1967; Jokippi 1966;Parker 1965, etc, whereas superposition effects may be studied from the point of view of Kahler 1969;McCraken and Rao 1970;McDonald 1970;McDonald et al. 1975, etc.

REFERENCES

Allum,F.R., Palmeira, R.A.P., Rao,U.R., McCraken,K.G., Harries,J.R.,Palmer, I. 1971, Solar Phys. 17, 241.

Anderson,K.A. 1969a, Proc. of the 11th Int. Conf. Cosmic Rays, 315.

Anderson,K.A. 1969b, Solar Phys. 6,111.

Axford,W.I., and Reid,G.C. 1963, J. Geophys. Res. 68 1793.

Bryant,D.A., Cline,T.L., Desai,U.D., and McDonald,F.B. 1962, J. Geophys. Res. 67,4983.

Bryant,D.A.,Cline,T.L., Desai,U.D., and McDonald,F.B. 1963, Phys. Rev. Letters, 11, 144.
Bryant,D.A.,Cline,T.L., Desai,U.D., and McDonald,F.B. 1965a, Goddard Space Flight Center, Greenbelt, Maryland,X-611-65-107.
Bryant,D.A., Cline,T.L., Desai,U.D., and McDonald,F.B. 1965b, Ap.J. 141, 478.
Dotlowe,D. 1972, J. Geophys. Res., 77, 5374.
Fan, C.Y., Pick, M., Pyle,R., Simpson, J.A., and Smith,D.R. 1968, J. Geophys. Res. 73, 1555.
Fermi, E. 1949, Phys. Rev., 75, 1169.
Gloecklen,G., Ipavich,F.M., Fan,C.Y., and Hovestadt,D. 1974, Geophys. Res. Letters, 1, 65.
Gold,T. 1959, J. Geophys. Res.,64, 1667.
Heristchi,D.J.,Trottet,G., and Pérez-Peraza,J. 1976, Solar Phys., 49, 151.
Kahler,S.W. 1969, Solar Phys., 8, 166.
Kinsey,J.H. 1970, Phys. Rev. Letters, 24, 246.
Krimigis,S.M. 1969, Proc. of the 11th Int.Conf. Cosmic Rays, 29, 125.
Lanzerotti,L.J. 1969, J. Geophys. Res., 74, 2851 .
Lanzerotti,L.J. 1974, Correl.Int. Phenomena, 345, Ed. Page.
Lin,R.P.,Khaler,S.W., and Roelof,E.C. 1968, Solar Phys.,4, 338.
McCraken,K.G.,and Rao,U.R. 1970, Space Sci. Rev., 11, 155.
McDonald,F.B. 1970, Intercor. Satel.Obs. Related to Solar Events, p. 34, Ed. by Manno and Page Reidel Publish. Co.
McDonald,F.B., and Desai,U.D. 1971, J. Geophys. Res., 76, 808.
McDonald,F.B.,Teegarden,B.J., Trainor,J.H., Van Rosevinge,T.T., and Webber,W.R. 1975, Ap. J., 203, L149.
McGuire,R.E., Lin,R.P., Anderson,F.A. 1975, Proc. of the 14th Int. Conf. Cosmic Rays.
Newrkirk,G. Jr., and Wentzel,D.G. 1977, Preprint.
Palmeira,R.A.R., Allum,F.R., and Rao,U.R. 1971, Solar Phys., 21, 204.
Parker,E.N. 1965, Phys. Rev. Letters, 14, 55.
Pérez-Peraza, J. 1977, to be published.
Rao,U.R., Allum,F.R., Bartley,W.C., Palmeira,R.A.P., Harries,J.A., McCraken,K.F. 1969, Solar Flares and Space Research, North-Holland, Amsterdam.
Rao,U.R.,McCraken,K.G., and Bukata,R.P. 1967, J. Geophys. Res., 72, 4325.
Roelof,E.C., and Krimigis,S.M. 1975, Rev. Geophys. Space Phys., 13, 1092.
Sarris,E.T., and Van Allen,J.A. 1974, J. Geophys. Res., 79, 4157.
Sarris,E.T., Krimigis,S.M., and Armstrong,T.P. 1976,Geophys. Res. Letters, 3, 133.
Schatzman,E. 1963, Ann. Astrophys., 26, 234.
Simnet,M., Cline,T.L., Holt,S.S., and McDonald,F.B. Acta Phys. Hung, 2, 141.
Singer, S., and Montgomery,M.D. 1971, J. Geophys. Res., 76, 6628.
Van Allen,J.A., and Ness,N.F. 1967, J. Geophys. Res., 72, 935.
Wentzel,D.G. 1962, Ap. J., 137, 135.
Wentzel,D.G. 1965, J. Geophys. Res. 70, 2716.
Wentzel,D.G. 1973, Astrophys. and Space Sci., 23, 417.
Wibberentz,G. 1971, Proc. of the 12th Int. Conf. Cosmic Rays, 204.
Wibberentz,G. 1976, Proc. Int. Symp. on Solar-Terrestrial Phys., Boulder, Colorado, 1, 346.