Further daemon detection experiments

E. M. Drobyshevski

A.F.Ioffe Physical-Technical Institute, Russian Academy of Sciences, 194021 St Petersburg, Russia

ABSTRACT

The experiments on detection of daemons captured into geocentric orbits, which are based on the postulated fast decay of daemon-containing nuclei, have been continued. By properly varying the experimental parameters, it has become possible to reveal and formulate some relations governing the interaction of daemons with matter. Among them are, for instance, the emission of energetic Auger-type electrons in the capture of an atomic nucleus, the possibility of charge exchange involving the capture of a heavier nucleus etc. The decay time of a daemon-containing proton has been measured to be $\Delta t_{\text{ex}} \approx 2 \mu s$. The daemon flux at the Earth’s surface is $f_\oplus \sim 10^{-7} \text{cm}^{-2}\text{s}^{-1}$. One should point out, on the one hand, the reproducibility of the main results, and on the other, the desirability of building up larger statistics and employing more sophisticated experimental methods to reveal finer details in the daemon interaction with matter.

Key words: black hole physics – dark matter – elementary particles – nuclear reactions – nucleosynthesis – proton decay.

1 INTRODUCTION. GENERAL IDEOLOGY AND THE RESULTS OF THE PREVIOUS EXPERIMENT

We reported earlier (Drobyshevski 2000c) on experimentally detecting indications of the existence of a flux of strongly-penetrating, nuclear-active particles moving with a velocity $\lesssim 10 \text{ km/s}$. The experiment supported our expectations aimed at a search for hypothetical DARk Electric Matter Objects, daemons, i.e., elementary Planckian black holes, which carry several (up to $Z_\text{d} \approx 10$) electronic charges and are part of the DM of the Galactic disk and, possibly, of the Universe as a whole.

Because of their large mass ($\approx 2 \cdot 10^{-5} \text{ g}$), daemons possess a giant penetrating ability. Nevertheless, as a result of the decelerating action of the matter they build up inside celestial bodies of the type of the Sun and the planets, as well as in helio- and planetocentric orbits. Due to their large charge, negative daemons are capable of catalyzing the fusion of light nuclei. The daemon-assisted proton fusion supplies apparently most of the Solar energetics and accounts for the electron-capture neutrino deficiency in the Solar flux (Drobyshevski 1996b). Bearing in mind the relativistic nature of the daemon, one could expect that the assumption of possible poisoning of its catalytic properties in the capture of heavy nuclei, similar to that expressed with respect to other particles (quarks etc.) (see, e.g., Salpeter 1970), would not prove to be correct. It could be anticipated that such nuclei (or their components) would either escape under the relativistic horizon of the daemon (Drobyshevski 1996a) or be ejected as a result of the decay of the component nucleons into which the daemon penetrated (Drobyshevski 2000a,b).

As follows from a comparison of the number of daemons captured by the Sun from the Galactic disc with their number required for the catalysis necessary to support the Solar luminosity, the time needed for a daemon to recover its catalytic properties inside the Sun is about $10^{-7} - 10^{-6}$ s (Drobyshevski 2000a,b). It remains unclear what is the real mechanism by which the daemon frees itself of a heavy nucleus. One could expect that the situation would become clearer as the experiments are continued in the direction chosen by us.

We assembled (Drobyshevski 2000c) an extremely simple setup for daemon detection based on the above two mechanisms of interaction of negative daemons with light ($Z_\text{d} \approx 10$) and heavy nuclei. It consists essentially of two transparent polystyrene plates, 4 mm thick and $0.5 \times 0.5 \text{ m}^2$ in area, coated on the bottom by a relatively thin ($3.0 - 3.5 \text{ mg/cm}^2$) layer of the ZnS(Ag) phosphor (its Ag content is $\sim 0.5 \cdot 10^{-4} \text{ g atom/mole ZnS}$). For an average phosphor grain size $\sim 12 \mu \text{m}$, this density provides a close-to-monolayer coverage with certain gaps between the ZnS(Ag) grains. The plates are light-isolated from one another by black paper and are mounted with a 7-cm spacing at the center of a cubic box of tinned sheet with an edge of 52 cm. Each plate is viewed by a PM tube from above and from below. Four identical modules, $1 \text{ m}^2$ in total area and arranged side by side in the same horizontal plane, were built altogether. We readily see that the system is asymmetric with respect to the vertical direction, thus permitting one
to judge the daemon flux direction and to draw conclusions on some properties of the radiations measured.

In the absence of a flux of particles causing scintillations, there should be no correlation between the signals of the PM tubes viewing the top and the bottom plates. In these conditions, the distribution $N_2(\Delta t)$ of the fairly rare (noise etc.) signals of the second (bottom) PM tube in the time shift $\Delta t$ between their beginning and the beginning of the signal from the first (top) PM tube can be approximated with a constant. An exception to this are the cosmic rays producing a strong maximum at $\Delta t = 0$, with the signals appearing frequently simultaneously in several modules. What we found, however, was a statistically significant maximum at $\Delta t \approx 20 - 40 \mu s$, which, while being totally unexpected from the standpoint of standard cosmic-ray physics, is exactly what had motivated the present experiment. It is due to signals from the bottom PM tubes, which arrive after the signals from the top (leading) PM tubes triggering the measurement system. One can infer also an existence of a leading maximum, i.e. a maximum with $\Delta t < 0$. It is much less significant and is shifted by $\Delta t \approx -(40 - 60) \mu s$. It is such maxima that were anticipated by us based on the daemon hypothesis.

These observations, besides indicating the existence of a new type of penetrating cosmic radiation, suggested that the velocity of the discovered particles is barely $\sim 5 - 10$ km/s, which should be characteristic of objects captured into geocentric orbits with a perigee inside the Earth. Their flux through the Earth’s surface reaches $\sim 10^{-5} - 10^{-7}$ cm$^{-2}$ s$^{-1}$.

We are presenting below a description of further experiments, which support our preliminary conclusions of the existence of daemons and shed light on some features of their interaction with matter.

However prior to going over to these results, we shall formulate the main postulates which permit a noncontradictory interpretation of our experimental data within the daemon concept. These postulates have formed to a considerable extent in the course of an analysis of the results themselves made on the basis of fairly general physical ideas.

### 2 MAIN ASSUMPTIONS CONCERNING THE INTERACTION OF NEGATIVE DAEMONS WITH MATTER

(a) A slowly-moving ($V \lesssim 100$ km/s) daemon impact neither ionizes nor excites the electronic shells of atoms. Therefore it cannot produce scintillations.

(b) In passing through matter, a daemon can capture an atomic nucleus. The ensuing drop of the nucleus to deeper levels in the electric field of the daemon will cause an Auger-type emission of electrons which initially surrounded the atomic nucleus.

(c) As the daemon continues to propagate through matter, it can capture a heavier nucleus while losing the old one (or its remnant, see below), again with emission of Auger electrons. The capture of a heavier nucleus is similar to the effect of charge exchange of ions moving through a gas, which is well known from the physics of gas discharge. Therefore as a daemon enters ZnS(Ag) from air or polystyrene, one should expect the light nuclei to become replaced by the S, Zn, and Ag nuclei and excitation of a scintillation. In this case the process of ‘charge exchange’ is more efficient for a larger mass difference between the exchanging nuclei.

(d) If the nucleus captured earlier by the daemon has a small mass and $Z_n \lesssim Z_d$, interaction of this complex with another light nucleus and the capture of the latter may culminate in nuclear fusion. Because of the internal conversion, the fusion energy has a high probability of becoming converted to the kinetic energy of the compound-nuclear thus formed, which escapes from the daemon. The daemon remains free afterwards for some time.

(e) If the daemon captures a light nucleus in a sufficiently rarefied (noncondensed) medium, for instance, in air, the light nucleus will not be able to shed the excess energy and, thus, may turn out to occupy such a high level as not even to be in contact with the daemon. (Recall that the lowest nucleus-daemon level for $Z_d = 10$ lies within the nucleus with $A \geq 2$, and inside the nucleus for $Z_n \geq 24/Z_d$.)

(f) It appears that the scintillations observed by us are primarily caused by the Auger electrons emitted in the capture of new atomic nuclei. We cannot at present maintain with certainty that what we detect are the nuclei released by the daemon and representing products of the fusion of light nuclei or particles produced in the decay of daemon-containing nucleons (or nuclei), although such events must certainly take place. Therefore we believe that as a daemon passes through a scintillator layer, the scintillation is primarily excited in the capture of a nucleus from the latter by the daemon, and by the resultant emission of Auger electrons. Scintillations are also produced in Auger electron emission and in the capture of a nucleus from outside the scintillator, if part of these electrons reaches the scintillator.

(g) The daemon-containing heavy nucleus decays apparently not in an explosive manner as we believed before (Drobyshevski 2000a,b), but rather step by step, nucleon by nucleon. Because a negative daemon should preferably reside in the protons of a nucleus, the decay most probably occurs in the proton-by-proton manner. The proton-by-proton disintegration should be accompanied by emission of excess neutrons from the nucleus. This gradual ‘digestion’ of the nucleus ends probably either in the decay (absorption?) of the last proton of the remaining tritium (or even of $^4$H) or in a capture of an encountered nucleus which is heavier than the disintegrating residual nucleus. Clearly enough, the nuclear decay time and the recovery by the daemon of its postulated catalytic properties are, on the whole, proportional to the initial nuclear mass; however in the presence of background matter from which another nucleus can be captured (for digestion or fusion with the remainder of the old one) this time depends to some extent on the nuclear properties of the surrounding matter.

While the first postulates are based on the relations known from atomic and nuclear physics, the latter (g) postulate follows already from our experiments.

### 3 INCREASING THE EXPERIMENT DURATION

The discovery of a nuclear-active radiation propagating with a velocity on the km-scale, i.e., of a population captured into particularly geocentric orbits, was somewhat unexpected for us. Therefore the next natural step was to increase the ob-
Figure 1. Distribution of the lower scintillator plate signals vs their time shift relative to the top scintillator signals. Time of exposure is ≈1000 hours.

The position of the first maximum (∆t ≈ 180 – 200 µs) yields ∼1.5 km/s for the velocity with which a daemon passes normally the distance of 29 cm from the lower box cover to the upper luminophor layer. Taking into account the random angular distribution of the trajectories, the average velocity increases to ∼3 km/s.

For ∆t > 0, the daemons move downward.

The first distinct maximum at ∼20 < ∆t < 40 µs corresponds apparently to the time needed for a daemon to cross the 7-cm gap separating the scintillator layers. For an arbitrary trajectory inclination, this time, as we saw before (Drobyshevski 2000c), corresponds to a velocity ∼3 – 5 km/s, i.e., to objects in geocentric orbits with a perigee inside the Earth. The interpretation of this maximum, as well as the −40 < ∆t < −20 µs maximum, should be approached with a certain caution, because the fairly slow digestion of nuclei by a daemon could give rise to a certain bias toward inclined trajectories. A daemon poisoned by a poorly digested heavy nucleus is less likely to capture a Zn or Ag nucleus from the next scintillator layer and to initiate a scintillation in it if it propagates by the fastest (direct) path. Another selection arises because of the higher probability of capture of Ag, despite its low content, by a slower-moving daemon (the capture cross section is proportional to V^{-2}).

Because of the ZnS(Ag) coating being not continuous, daemons with nuclei captured both in the upper scintillator have a fairly high probability of turning up also in the space under the bottom scintillator. Therefore in order to reliably separate and subsequently identify the maxima according to their origin (the end of digestion of a Zn or Ag nucleus captured in the top or bottom scintillator etc.) for ∆t ≥ 40 – 60 µs, the statistics of the events should be much larger than they are presently. Nevertheless, there are grounds to believe that the maximum which is just barely discernible near +100 µs is due to the decay of the Ag captured in the top ZnS(Ag) scintillator, and that the maximum at ∼180 < ∆t < 200 µs for the daemons propagating downward, has the same origin as the one at −160 > ∆t > −180 µs, i.e., interaction of the upward-moving daemons with the tin coating of the lower part of the box (in this case, however, the Auger electrons are certainly emitted from the thin tin layer in the capture of Sn nuclei). There is no Zn maximum in the +(40 – 80) µs interval, because most of the captured Zn nuclei disintegrate before entering the second scintillator layer. Recall that we selected in the oscillograms only the events that contained one signal.

4 EXPERIMENT WITH ADDITIONAL TINNED-IRON SHEETS

To verify once more that what we detect in these experiments are not artifacts but real reproducible events, we placed into the gap between the top and bottom phosphor layers a 0.25-mm thick sheet of tinned iron in all the four
modules. The thickness of the tin layer on each side of the sheet was \( \sim 2 \mu m \). This sheet was placed directly on the black paper providing optical isolation of the scintillator layers from one another, so that it was 5 mm above the bottom scintillator.

The experiment was run for 550 h. It was performed after the experiment with the \( \pm 100 \mu s \) time interval (Drobyshesvki 2000c) and before the one with the \( \pm 250 \mu s \) interval, which is described in Section 3 and demonstrates also the reproducibility of the main results within the \( \pm 100 \mu s \) interval.

We expected that the tinned sheet, because of the presence in it of Fe and Sn nuclei, would strongly affect the \( N_2(\Delta t) \) distribution obtained in the conditions where heavy nuclei are contained only in the ZnS(Ag) layers.

This was exactly what happened. The distribution for \( \Delta t < 0 \) became substantially more monotonic (Fig. 2). It no longer exhibits individual, fairly sharp maxima evident in Fig. 1. One sees actually one, closely filled maximum extending from -160 to 0 \( \mu s \). If the statistics were larger, there would probably appear traces of the old maxima. As it is, one can only maintain that charge exchange in the thin tin layer of the additional tinned sheet accompanied by a loss of remnants of Zn and Ag nuclei and a capture of \( \sim 119 \text{Sn} \) heavy nuclei proceeds apparently so efficiently that the upward moving daemons deliver without loss only remnants of these Sn nuclei to the top scintillator. And it is only here that these remnants are replaced by Ag (and Zn) nuclei to initiate the triggering scintillation. Recalling that the distribution for \( \Delta t < 0 \) is filled up to \( \Delta t \rightarrow 0 \), one could conjecture that some (triggering) scintillations in the top ZnS(Ag) layer are caused by the Auger electrons escaping from the thin top tin layer of the sheet when a daemon captures a Sn nucleus in it. We may recall that electrons of energy \( \sim 0.1 - 1 \text{ MeV} \) are capable of passing through a 2-\( \mu \text{m} \) layer of tin while being stopped by a 0.25-mm layer of iron or by 4 mm of polystyrene.

The part of the \( N_2(\Delta t) \) distribution for \( \Delta t > 0 \), which characterizes the downward daemon flux also differs from the corresponding distribution in Fig. 1.

Note the dip at \( 0 < \Delta t < 40 \mu s \), after which a peak at \( 40 < \Delta t < 60 \mu s \) appears. This dip can be readily interpreted as due to screening by the tinned sheet of the bottom ZnS(Ag) scintillator. In passing through the sheet, the daemon becomes poisoned by, say, a Fe nucleus (\( Z_n = 26 \)), and therefore does not excite the ZnS(Ag) layer. Only after the traversal of the ZnS(Ag) layer and digestion of the iron nucleus in \( \Delta t \approx 26 \times 2 \mu s \approx 50 \mu s \) the daemon captures a nucleus in the air and generates Auger electrons, that excite the bottom scintillator layer. Therefore even in the presence of fast daemons the width of the dip should not depend on specific features of their velocity distribution.

The depth of the dip at \( 0 < \Delta t < 40 \mu s \) characterizes apparently the noise level in the given \( N_2(\Delta t) \) distribution. But then, as follows from the \( N_2(\Delta t) \) histogram in Fig. 2, the number of events initiated by daemons during the time of observation is 193 (taking into account errors, it could be reduced to \( \sim \)one third this figure). This yields for the measured daemon flux \( f_0 \approx (0.3 - 1) \times 10^{-8} \text{ cm}^{-2} \text{s}^{-1} \). In view of the fact that the level \( (U_1 \gtrsim 2.5 \text{ MeV} \) of the triggering pulses is three times that of the second-trace signals \( U_2 \gtrsim 0.8 \text{ mV} \) we select, and that the frequency of the pulses is proportional to the cube of their amplitude, we obtain for a probable estimate \( f_0 \sim 10^{-7} \text{ cm}^{-2} \text{s}^{-1} \).

Accumulation of larger statistics will hopefully reveal in the \( N_2(\Delta t) \) dependence (for \( \Delta t > 0 \)) maxima corresponding to the decay of Sn, Ag, and Zn, as well as permit determination of the daemon distribution in velocities from the \( N_2(\Delta t) \) plot obtained without iron shields.

5 SOME CONCLUSIONS AND PROSPECTS

We have succeeded in developing a nonstandard method of detection of daemons through the understanding of the fact that the fundamental nonrelativistic nature of these particles permits them to recover their catalytic properties in a relatively short time by shedding the captured massive nucleus in a still unknown manner. Using fairly simple, not to say primitive handy means, we revealed definite and largely expected indications of the existence of daemons. Their low velocity was not anticipated, however. It is characteristic of a population captured by the Earth. The flux of this population through the Earth’s surface is \( f_0 \sim 10^{-7} \text{ cm}^{-2} \text{s}^{-1} \), possibly.

The results produced by varying the experimental conditions were likewise largely anticipated, which suggests that our ideas concerning the properties of daemons are, on the whole, correct, and that we correctly understand what happens when we change the parameters of the setup and the conditions of observations. A similar experiment repeated months after the preceding one demonstrates a good reproducibility.

A thorough analysis of the data obtained has permitted formulation of a number of fairly obvious postulates governing the behavior of daemons in matter (decay of nucleons and recapture of heavier nuclei, Auger electron emission etc.).

Besides the confirmation of the discovery of daemons itself and of their Earth-bound population, this work has culminated in a fundamental result of an actually direct measurement of the decay time of a daemon-containing proton. It was found to be \( \tau_{ex} \approx 2 \mu s \). This value is larger by at least an order of magnitude than the figure for the average time for the daemon to shed a heavy nucleus \( (\tau_{ex} \sim 10^{-5} - 10^{-6} \text{ s}) \), which was obtained by us.
Further daemon detection experiments

from an analysis of the Solar energetics (we may recall that
\[ \Delta \tau_{ex} \approx \frac{\tau_{ex}}{Z_n} \].

Because \( \Delta \tau_{ex} = \text{const} \) characterizes the decay time of
one proton, we have actually discovered a daemon-associated
method of determining \( Z_n \) of the substance through which
it passes and whose nuclei it captures.

It should be admitted that because of the statistical na-
ture of the results we obtain we just have to work close to
the confidence level in order to reach as rich an understand-
ing of the essence of the observed phenomena as possible
in a minimum time. It is thus obvious that one has to ac-
cumulate as statistically reliable material as possible while
simultaneously improving the detection system and vary-
ing its parameters. Richer statistics will permit refining this
important parameter, \( \Delta \tau_{ex} \), as well as revealing and mak-
ing more reliable new features in the distribution of events
happening between remote scintillation detectors from the
corresponding time delays. Some of the conclusions made
by us here will possibly have to be modified. As a result,
one will be able to determine the daemon distributions in
velocity and directions and their long-period variations, as
well as to reveal finer details in the interaction of daemons
with various components of the material and, more gener-
ally, with matter as a whole. To reach the latter goal, one
would naturally have to use more sophisticated techniques
of nuclear physics than those employed by us thus far. Ob-
viously enough, daemons would themselves serve as a com-
pletely new tool to probe processes on both the subnuclear
and cosmological scales.

ACKNOWLEDGMENTS

The author is greatly indebted to M.V.Beloborodyy,
R.O.Kurakin, V.G.Latypov and K.A.Pelepelin for assistance
in experiments.

REFERENCES

Drobyshevski E.M., 1996a, On interaction of black miniholes with
matter. Preprint PhTI-1663, Ioffe Phys.-Tech. Inst., St Peters-
burg
Drobyshevski E.M., 1996b, MNRAS, 282, 211
Drobyshevski E.M., 2000a, MNRAS, 311, L1
Drobyshevski E.M., 2000b, Phys. Atomic Nuclei, 63(6), 1037
Drobyshevski E.M., 2000c, Daemon detection experiment, MN-
RAS (submitted to), [astro-ph/0007370]
Salpeter E.E., 1970, Nat, 225, 165

© 2000 RAS, MNRAS 000, 1–5