Mini Review

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Linear acceleration of protons on a backward wave (Bogomolov's accelerator)

Abstract

The article proposes to consider fundamentally new way of accelerating charged particles: linear acceleration (LA) of protons on a backward wave (Professor Bogomolov's Accelerator). The article discusses the advantages and scope of the new accelerator. The European Strategic Group (ESG) is considering fundamentally new projects to create more efficient and less expensive accelerators and colliders for research.

Keywords: linear accelerator, backward wave, proton, electron, neutron.

Volume 6 Issue 4 - 2022

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Received: July 30, 2022 | **Published:** August 24, 2022

Introduction

The article proposes a particle acceleration project based on completely new physical principles: the acceleration of protons on a backward wave (Professor Bogomolov's accelerator). In fact, in all projects of the last 30 years, the developers of linear accelerators focused on the capabilities of the SCS. In particular:

a) in the USA (2006) the world's most powerful proton laser was created - a source of neutrons - SNS (proton energy 1 GeV, power 1.56 MW, length 258 m);

b) in the USA (2008-2018) a multifunctional 8 GeV ion DL (L=692 m) is being created;

c) The European Community (2010-2018) is designing the ESS neutron complex at the beam of the H-linear proton accelerator with an energy of 1.33 GeV and a beam power of 5 MW;

d) China, India, Japan, South Korea are implementing programs based on the creation LAP for fundamental and applied research that determines the future of AE.

In these programs, the accelerators are "single-technology" - all on superconductivity. The creation of these accelerators consumes billions of dollars of resources. Designs of "warm" LA (for ADS), different from traditional schemes, not discussed anywhere. According to the author last known a serious discussion of the problem was at EPAC-96.[1] The modern scientific literature contains a guiding statement that is widely spread throughout the world community of accelerator technology developers: "in "warm" versions of LA, the efficiency is low, and a small aperture (diameter of the accelerator channel) is a problem in terms of beam losses, which, moreover, are not localized". It is this kind of assertion that forced the bulk of the creators of LAs to develop superconducting (SP/SC) accelerator complexes. As a result, since the beginning of the 1990s, serious analysis and publications on the development of superpower linear accelerators that could be performed on LA structures at room temperature (~300 K) have practically disappeared. This erroneous opinion is completely refuted by the theoretical work of Professor Alexei Bogomolov and the successful operation of the backward wave proton accelerators he created.[2]

The accelerator of elementary particles on the backward wave of alexy Bogomolov

Today, more urgent than ever, the task of life support for mankind cheap and reliable sources of energy (electricity and heat) and getting rid of accumulated amounts of radioactive waste and fears associated with the use of nuclear energy. Nuclear power in reactors with a self-sustaining reaction causes a wary attitude towards it both by the population and professionals. Control, maintenance of operability and safety, and management of all processes in subcritical reactors are carried out by beams of high-energy protons. This fundamentally distinguishes subcritical reactors from modern ones reactors and completely excludes Chernobyl-type reactivity radioactive accidents. Instead of maintaining a chain reaction, a subcritical reactor uses additional neutrons from an external source. There are two main classes of such devices. One uses the neutrons given off by a nuclear fusion machine, a concept known as a hybrid of fusion and fission. The other uses neutrons created by the fission of heavy nuclei by charged particles such as protons accelerated by a particle accelerator, a concept known as an accelerator driven system (ADS) or accelerator driven subcritical reactor. In the article "BWLAP's versa SC-Linacs", Professor Aleksey Bogomolov presents the materials of his fifty years of research aimed at creating ADS - an accelerating nuclear installation for industrial use, on the topic of BWLAP (reverse wave linear particle accelerator), in relation to the problem of creating a compact proton accelerator at high-performance linear accelerators of "room temperature" with a clearly expressed inverse spatial harmonic of a high-frequency electromagnetic field propagating against the flow of the accelerated particles.[2] It proves the BWLAP (with water-cooled accelerator structures) advantage over superconducting accelerators in general efficiency (Pbeam/PAC) at analogous energy of protons. Application of BWLAP appropriate in the complexes with sub-critical nuclear reactors for transmutation the radioactive waste (RW) and blowing minor actinides, and to produce nuclear energy. A modular three-dimensional back-wave accelerator producing a huge stream of protons can become a formidable weapon. The BWLAP can provide the regime with a low duty cycle and continuous-wave operation. A group of researchers led by Professor Aleksey Bogomolov developed a technology for accelerating positively charged particles (protons, deuterons) on a backward wave - BWLAP (Figure 1). The essence of this technology is the acceleration of elementary particles by the electric component of an electromagnetic wave traveling in the same direction and at the same increasing speed as accelerated ions. In this case, the source of electromagnetic waves is installed at the end of the accelerator, which is opposite to the injection one, and the wave runs towards the energy flow - thereby the wave (spatial harmonic) is oppositely directed with respect to the direction of the energy flow.

The article[2] by Professor Alexei Bogomolov discusses the achievements in the development of linear accelerators based on highly efficient "thermal" frequency structures, the value of the overall and electronic efficiency and the loss of particles during their acceleration in BWLAP's.

Accelerator complexes, if they are implemented according to the reverse wave accelerator scheme with a heat removal system with room temperature water, will provide power in accelerated proton beam ~ 2-3 (30) MW and proton energy 1-10 GeV and will have a huge superiority compared to accelerators based on superconducting structures.[2]

Figure 1 Alexey Bogomolov's mobile modular 3D reverse wave accelerator.

The acceleration method on the inverse spatial harmonic allows:

i. Solve the problem of longitudinal and transverse stability of accelerated protons;

ii. Carry out 95% capture of the proton beam injected into the accelerator into the mode of stable acceleration;

iii. Increase by 10 times the frequency of the HF field accelerating protons and carry out acceleration in the decimeter wavelength range;

iv. Reduce the longitudinal and transverse dimensions of the accelerating structures by more than an order of magnitude;

At the same time, accelerators based on the proposed acceleration principle have a number of advantages compared to traditional linear accelerators:

i. The absence of superconducting structures in the design and the use of traditional water cooling;

ii. Significantly smaller dimensions of the accelerator with comparable power;

iii. High energy of the accelerated beam - more than 1 GeV;

iv. Higher efficiency of the installation - 34% instead of 16% in traditional accelerators.

Possible applications of accelerators based on the proposed acceleration principle:

i. Transmutation, disposal of radioactive waste;

ii. Nuclear power: 1) creation of subcritical nuclear reactors with an external source of neutron radiation;

iii. Medicine: 1) proton beam therapy for oncological, paraspinal and neurosurgical diseases; 2) production of radiopharmaceuticals, incl. for early diagnosis of diseases;

iv. Materials science: 1) production of isotopes for industrial needs; 2) production of high-purity chemical compounds for microelectronics and electrooptics; 3) defekstoscopy; 4) processing of materials, changing their physical and chemical properties

v. Detection of explosive, narcotic and fissile materials.

That is, we are dealing with the invention of the AGE. The Bogomolov accelerator on the backward wave allows, due to the interaction of the proton beam with a thick target (cleavage reaction), to obtain a high-density neutron flux capable of dividing U-238. When used in the energy sector, we can get something similar to a fast neutron reactor, but generating heat without a chain reaction and the presence of a critical mass. The reactor becomes small, useless for terrorists and other villains, because. there is no critical mass. There is no danger of uncontrolled dispersal of the rector, as was the case in Chernobyl, because no chain reaction. The reactor can simply be turned off at any time, without even worrying about the removal of residual heat from the daughter isotopes, since the latter are few in comparison with a conventional reactor. They are burned directly in the process of work. And finally, we no longer need uranium enrichment plants, because. all this beauty works on a natural mixture of isotopes.

Attention, the question is - why does such a great thing exist only in the form of separate laboratory installations and is not used in industry? And it's not just technical problems. With such bonuses, any technical problems can be overcome. So there is something else. And that something is the existing reactors. More specifically, their safety. After all, a modern reactor is uranium rods, which are 95% U-238 oxide. The one that is perfectly divided by fast neutrons. And what, one wonders, will happen if such a reactor gets into a beam of fast neutrons? A fission reaction will begin in it, which will lead to heating of the core. It is impossible to stop the reaction by means of the reactor block itself. You can only remove the generated heat and hope that the power of the pumps is enough for this. But, this is if you are ready and understand what is happening! If exposure to fast neutrons from outside turns out to be a surprise, then it will be so, because no one walks around the country with fast neutron generators and does not irradiate reactor blocks with them! So, in the event of an unexpected irradiation, the heat release of the reactor will increase, the neutron detectors will howl, and the automation will drop the protective rods. But, this will not change anything, because. the neutron source is outside the reactor. Heating will continue, the core will melt and a thermal explosion will occur. The reactor will cease to exist. It would seem a fantastic prospect, because the reactor has a thick outer vessel, which should stop the flow of neutrons. After all, it is he who stops those neutrons that are formed inside the reactors and protects people from radiation damage? But, unfortunately, we are talking about neutrons with relatively low energies. The fastest of them are 100 times slower than those neutrons that can be obtained

Citation: Konstantinov S. Linear acceleration of protons on a backward wave (Bogomolov's accelerator). *Phys Astron Int J.* 2022;6(3):105‒107. DOI: 10.15406/paij.2022.06.00261

using a backward wave accelerator. Naturally, reactor protection is not designed for such energies.

Conclusion

Proposed for consideration by the European Strategic Group (ESG), new physical methods of particle acceleration can significantly increase the efficiency of charged particle accelerators, while significantly reducing the cost of their manufacture and operation.

Aknowledgements

The author thanks for the fruitful discussion of the Professor Alexey Bogomolov and mourns his untimely death.

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Citation: Konstantinov S. Linear acceleration of protons on a backward wave (Bogomolov's accelerator). *Phys Astron Int J.* 2022;6(3):105–107.
DOI: 10.15406/paij.2022.06.00261