Нова енергетика, перспективи енергетичної незалежності України

Д.ф.-м.н., проф. зав. кафедри математики та теоретичної радіофізики факультету радіофізики, електроніки та комп'ютерних систем
Володимир Іванович Висоцький.

Ситуація в Україні:
АЕС – 50% виробництва електроенергії, Теплові – 40%, ГЕС – 10%

электростанции показан на рис. 10.

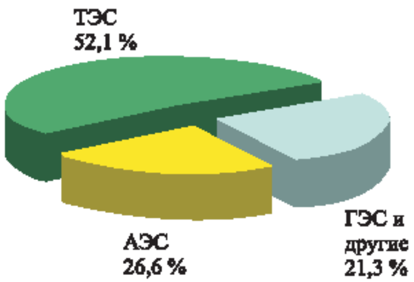


Рис. 8. Установленные мощности генераций, которые находятся в эксплуатации

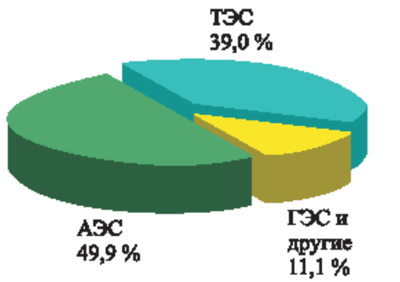


Рис. 9. Удельный вес отпуска электроэнергии на оптовый рынок Украины по видам генерации

Запоріжська АЕС: ВВЕР-1000, 1984
ВВЕР-1000, 1985
ВВЕР-1000, 1986
ВВЕР-1000, 1987
ВВЕР-1000, 1989
ВВЕР-1000, 1995

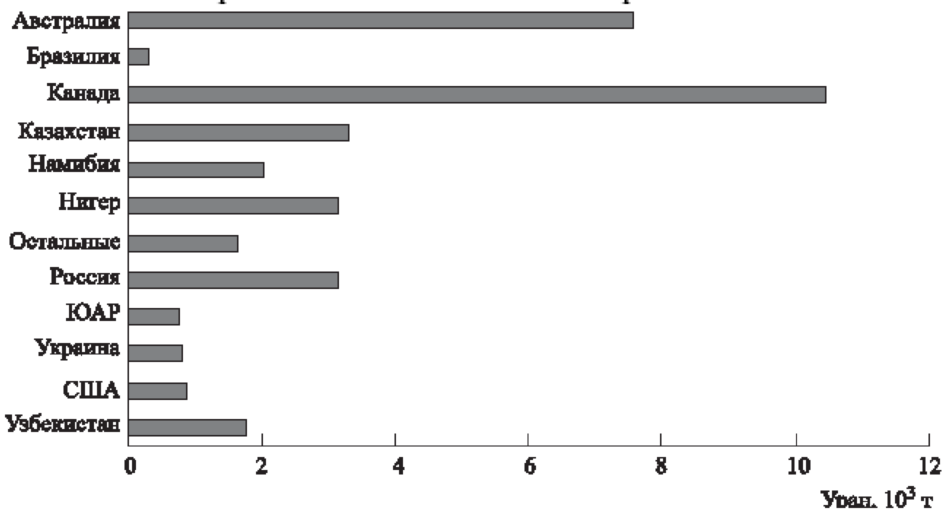
Рівненська АЕС: ВВЕР-440, 1980
ВВЕР-440, 1981
ВВЕР-1000, 1986
ВВЕР-1000, 2004

Південно-Укр. АЕС: ВВЕР-1000, 1982
ВВЕР-1000, 1985
ВВЕР-1000, 1998

Хмельницька АЕС: ВВЕР-440, 1987
ВВЕР-1000, 2004

Понад 30 років (100% планового терміну експлуатації)
Понад 15 років (50% планового терміну експлуатації)
Менше 15 років (менше 50% планового терміну експлуатації)

Рис. 13. Схема размещения объектов ядерного топливного цикла Украины



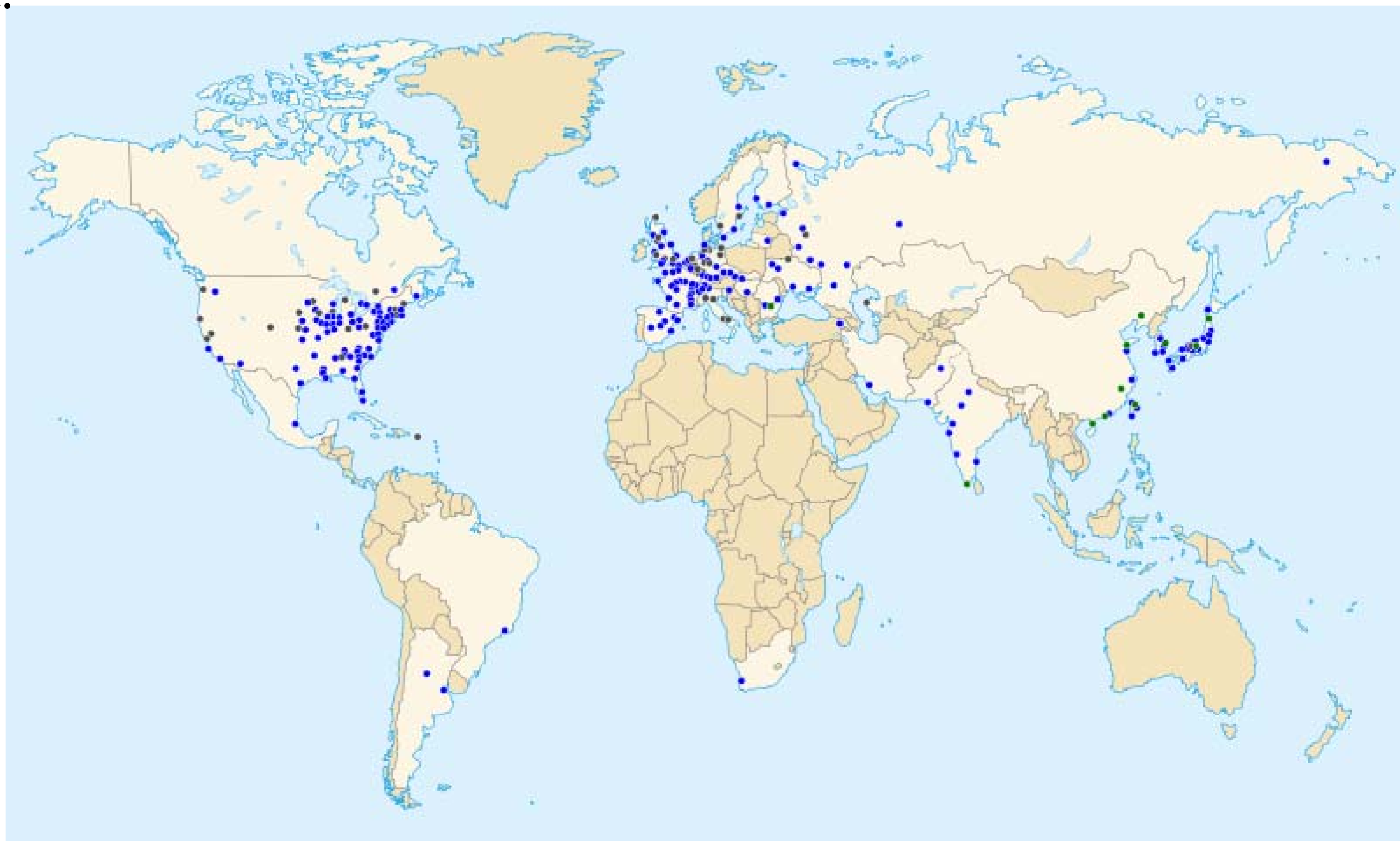
Problems of modern nuclear industry

Now in the world there are **368 active industrial nuclear reactors**:

(USA- 104; France-58, Japan-50,Russia-33, S.Korea-21, Ukraine-15);

3 - are building,

138 – are closed.



Now in the world there are **more than 250 000 tons of spent reactor fuel (high-level radioactive waste) and 15 000 tons/year**

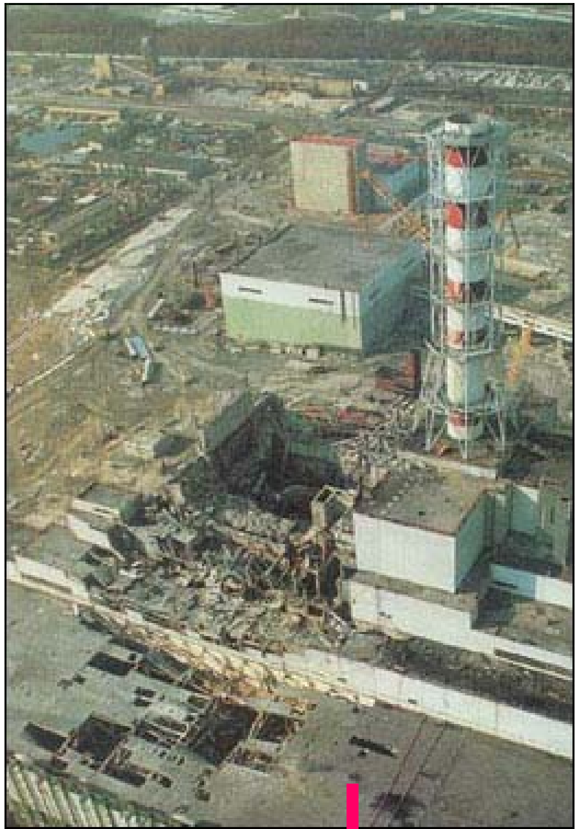
Besides, in each reactor there are thousands tons of highly active water (more than **1 000 000 tons of highly active water in the world**).

Besides, in the world there are about **10 000 000 tons of low active waste.**

Radioactive waste	β, γ	α (without transuranium)	α (transuranium)
Low-level waste	$<10^6$ Bq/kg	$<10^5$ Bq/kg	$<10^4$ Bq/kg
Medium-activity waste	$10^6 \ldots 10^{10}$ Bq/kg	$10^5 \ldots 10^{10}$ Bq/kg	$10^4 \ldots 10^8$ Bq/kg
High-level radioactive waste **(need cooling)**	$>10^{10}$ Bq/kg	$>10^{10}$ Bq/kg	$>10^8$ Bq/kg

The typical components of high-level radioactive reactor waste

Isotope	Half-life	Activity (in relation to Pu^{239})	Main decay mode
Sr^{90}	**28.5 years**	**Q=230**	**β-**
Zr^{95}	64 days	Q = 5800	β-
Nb^{95}	35 days	Q = 5700	β-
Mo^{99}	66 hours	Q = 6100	β-
Ru^{103}	39 days	Q = 3800	β-
Ru^{106}	373 days	Q = 860	β-
Sb^{125}	2.8 years	Q = 150	β-
I^{131}	8 days	Q = 3100	β-
Cs^{134}	2 years	Q = 170	β-
Cs^{137}	**30.03 years**	**Q = 260**	**β- (and γ)**
Ce^{144}	285 days	Q = 3900	β-
Eu^{154}	8.8 years	Q = 14	β-
Pu^{238}	87.7 year	Q = 1.3	α
Pu^{239}	24000 years	Q = 1	α
Pu^{240}	6550 years	Q = 1.5	α
Pu^{241}	14.4 years	Q = 180	α
Am^{241}	432 years	Q = 0.16	α



The April 26, 1986 accident at Chernobyl.

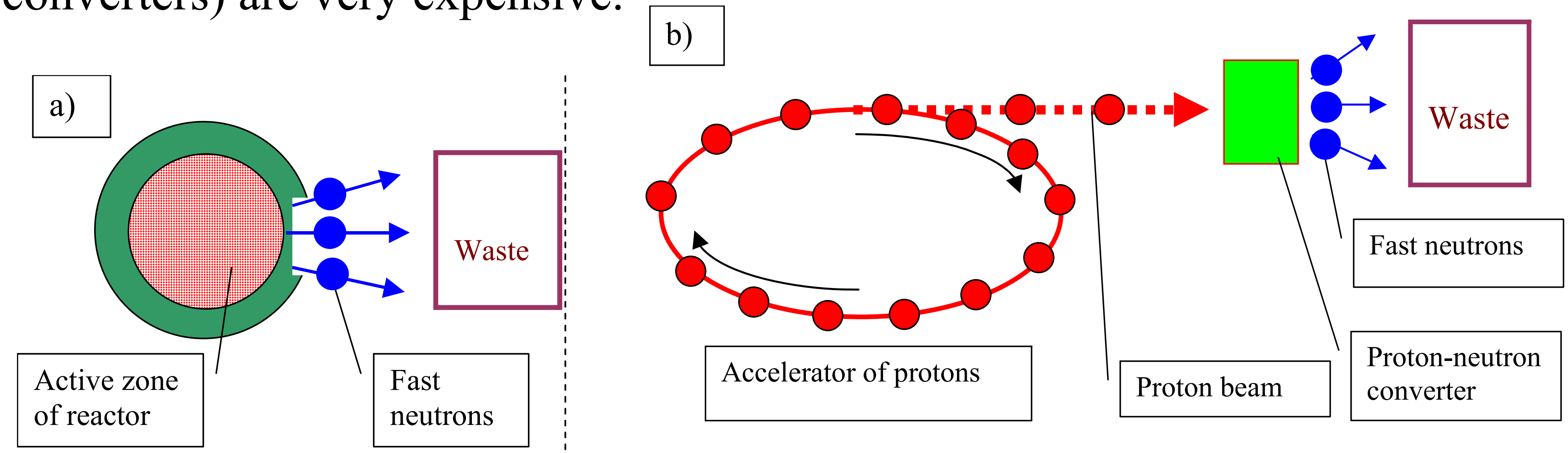
Four hundred times more radioactive material was released than in the atomic bombing of Hiroshima.

Effects of FUKUSHIMA

Unfortunately these very effective MCT associations can't grow in sea (salt) water and can't be used for deactivation of radioactive water in anaerobic condition (e.g. in Fukushima area)!

Radioactive water and soil: water – 350 000 tons+350 tons/day; soil - about 500-700 ktons

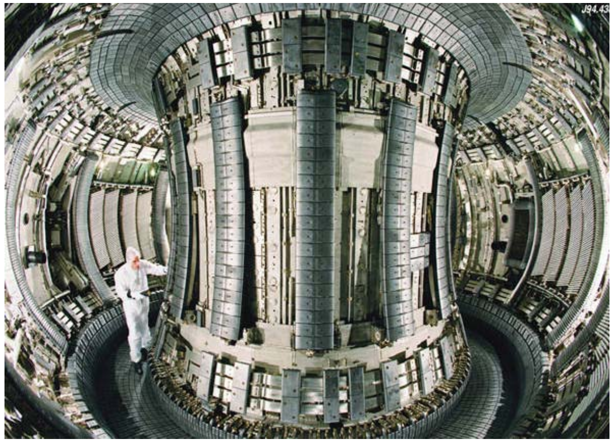
There are different possible methods of utilization of these waste. Traditional way of utilization (transmutation of radioactive waste to different stable isotopes by action of neutron beams created in proton-neutron converters) are very expensive.



The total cost of both scientific and technologies parts of such solution of the utilization problem (USA, Japan, Russia, France, UK, S.Korea) is about $30-50 billions during 2010-2050!

Another essential drawback of this program is the following: **at such neutron action on highly radioactive waste a great amount of additional low active waste is formed in environment.**

ТОКАМАК



$$_1t^3 +_1 d^2 =_2 He^4 + n + 17.6\,Mev$$

Всего в мире было построено около 300 токамаков.

СССР и Россия: Т-10 и PLT — T=10 keV, $n\tau/(n\tau)_{cr}$=1/200; Т-15 — H= 3,6 Тл.

Китай: EAST — расположен в городе Хэфэй, провинция Аньхой. На токамаке превышен критерий Лоусона по уровню зажигания.

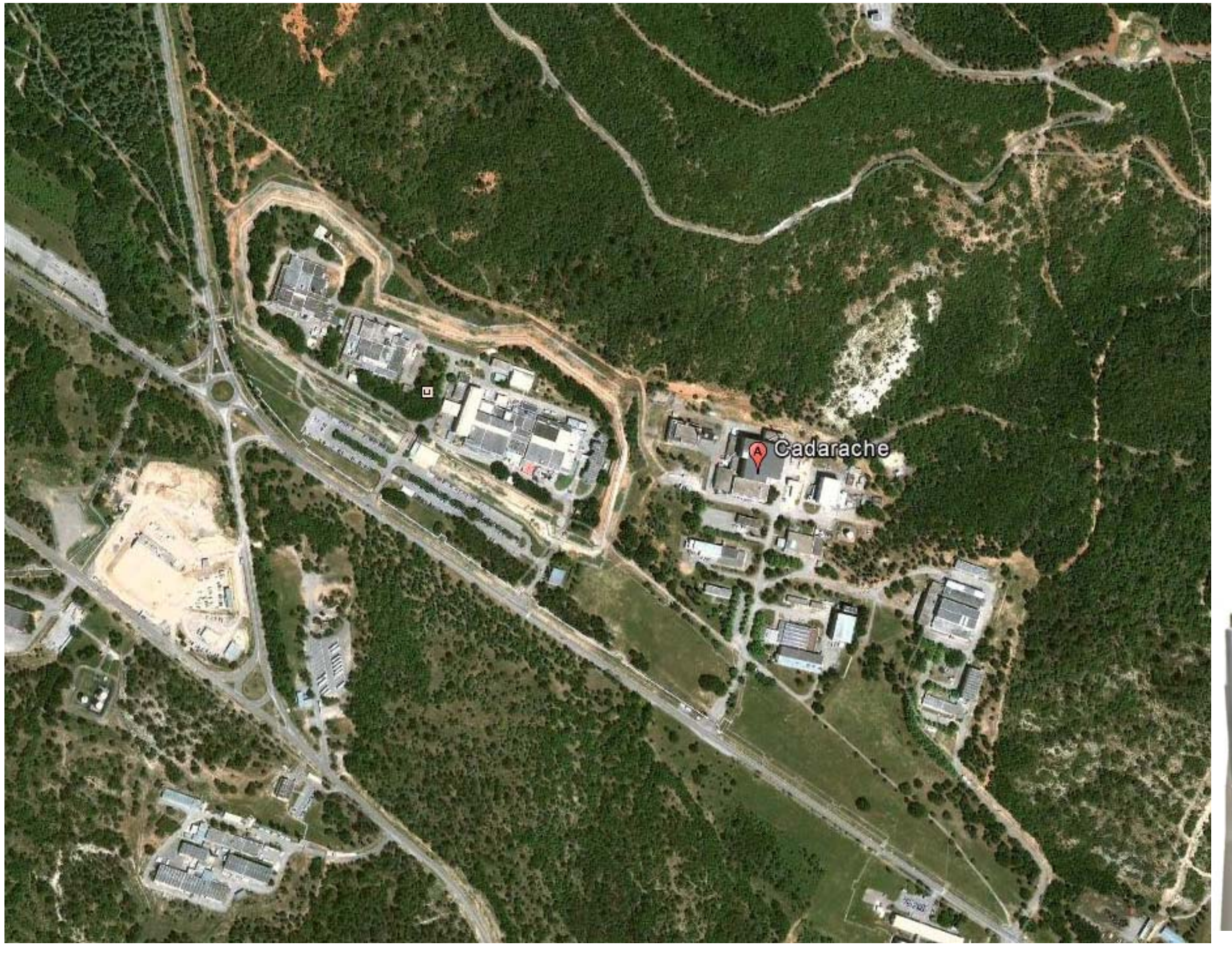
Европа и Великобритания: JET (Joint European Torus) — созданный организацией Евратом в Великобритании. В нём использован комбинированный нагрев: 20 МВт — нейтральная инжекция, 32 МВт — ионно-циклотронный резонанс. Критерий Лоусона в 4—5 раз ниже уровня зажигания; Tore Supra — токамак со сверхпроводящими катушками. Находится в исследовательском центре Кадараш (Франция).

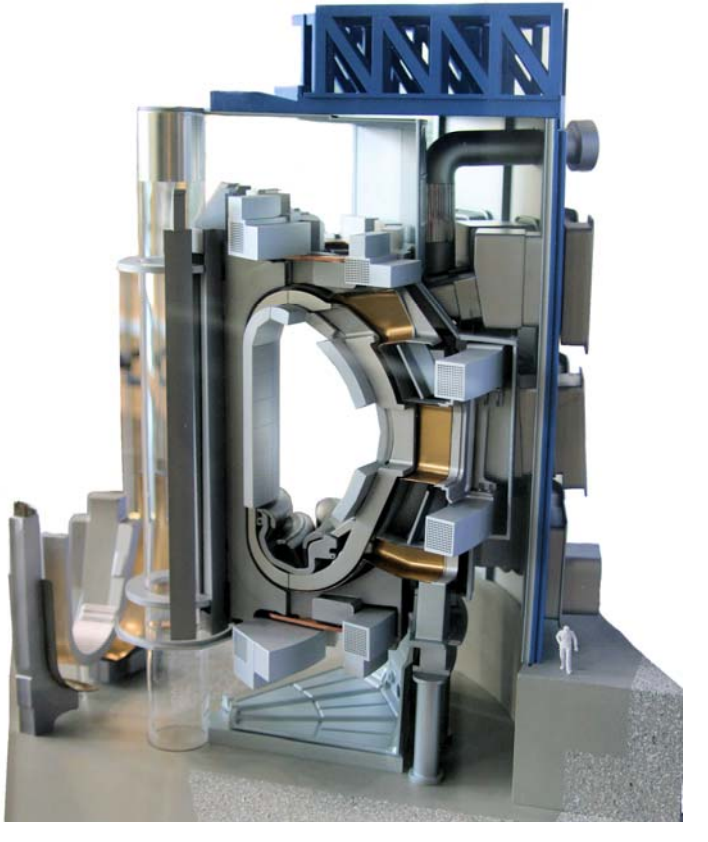
США: TFTR (Test Fusion Tokamak Reactor) — самый большой токамак в США (Принстонский университет) с дополнительным нагревом быстрыми нейтральными частицами. Критерий Лоусона в 5,5 раза ниже порога зажигания. Закрыт в 1997 г. NSTX (National Spherical Torus Experiment) — сферический токамак (сферомак) работающий в настоящее время в Принстонском университете. Первая плазма в реакторе получена в 1999 году, через два года после закрытия TFTR.
Alcator C-Mod— Alcator C-Mod характеризуется самым высоким магнитным полем и давлением плазмы в мире. Работает с 1993 г. ; DIII-D (— токамак США, созданный и работающий в компании General Atomic в San Diego.

Япония: JT-60 — работает в Институте ядерных исследований с 1985 г.

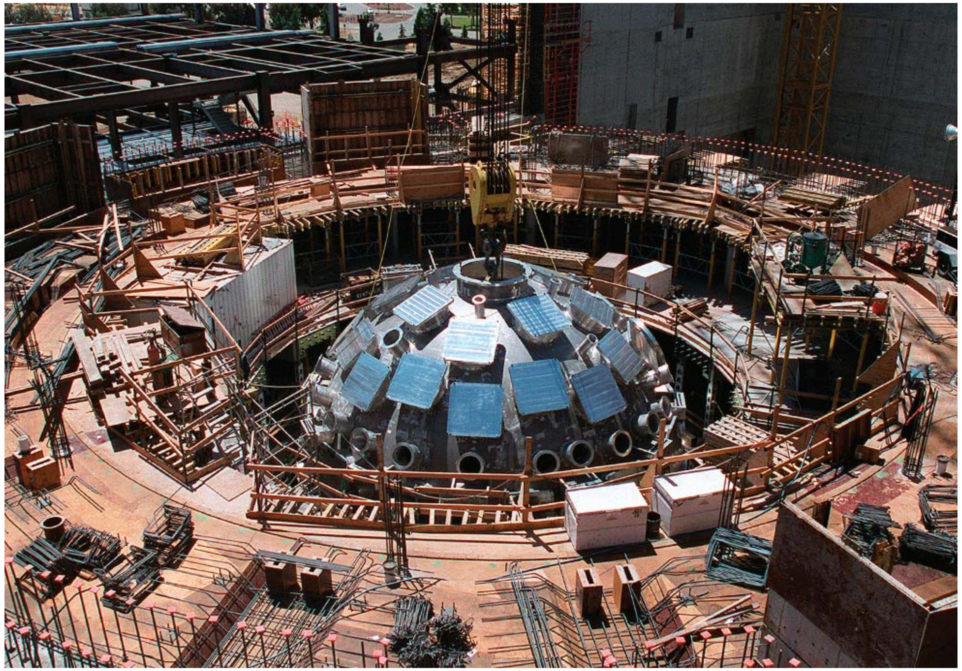
ITER (EU, USA, Russia, India, Japan, China, S.Koria);
Cadarache (France): Cost - $15 000 000 000.

Stages: 2007-2019 – building;2019-2037 – experiments; >2037 – activity
$R_{plasma\ tor}$=6.2 m, V_{plasma}=837 m^3, H=5.3 T, J_{max} =15 MA,
P_{in}=40MW, P_{out}=500MW, T=100 MK=10keV, τ_{pulse}=400 s





Inertial (d,t) fusion



Livermor National Lab (CA)
National Ignition Facility, 2012
Cost – 4 B$=$4 000 000 000

192 KrF (green) Laser beams
W_{tot}=192*26KJ=5 MJ,
τ=23 ns, P_{tot}=250 TW

Diameter of DT gas target – 2 mm,
$T_{initial}$ =18K; T_{final}=10keV,
Final density - 1000g/cm^3

Сонячна ьа вітрова енергетика

Достоинства

1. Перспективность, доступность и неисчерпаемость источника энергии в условиях постоянного роста цен на традиционные виды энергоносителей.
2. Теоретически полная безопасность для окружающей среды

Недостатки

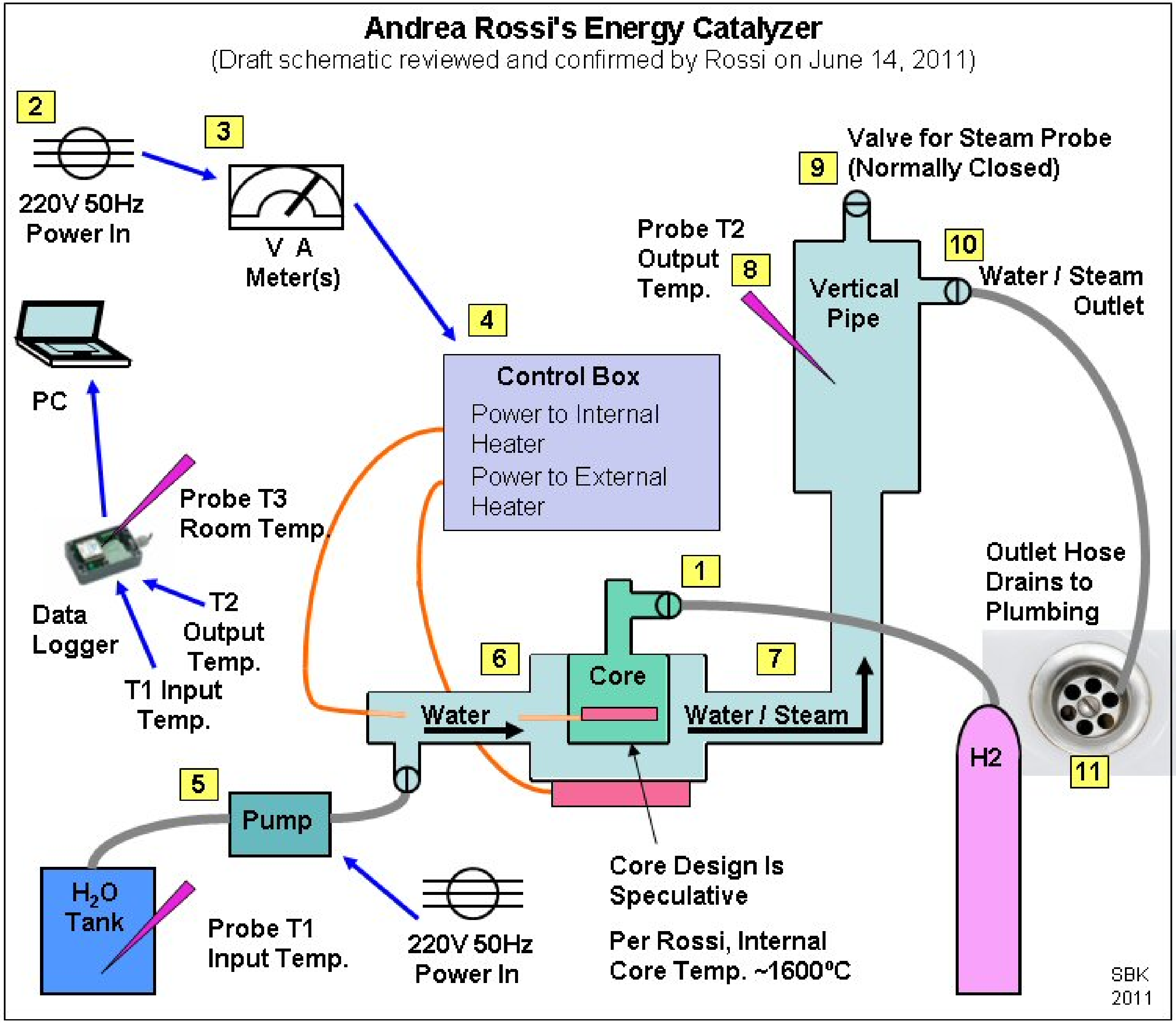
1. Зависимость от погоды и времени суток.
2. Сезонность в средних широтах и несовпадение периодов выработки энергии и потребности в энергии. Нерентабельность в высоких широтах.
3. При промышленном производстве — необходимость дублирования солнечных ЭС маневренными ЭС сопоставимой мощности.
4. Высокая стоимость конструкции, связанная с применением редких элементов (к примеру, индий и теллур).
5. Экологические проблемы при изготовлении фотоэлементов
6. Необходимость периодической очистки отражающей/поглощающей поверхности от загрязнения.

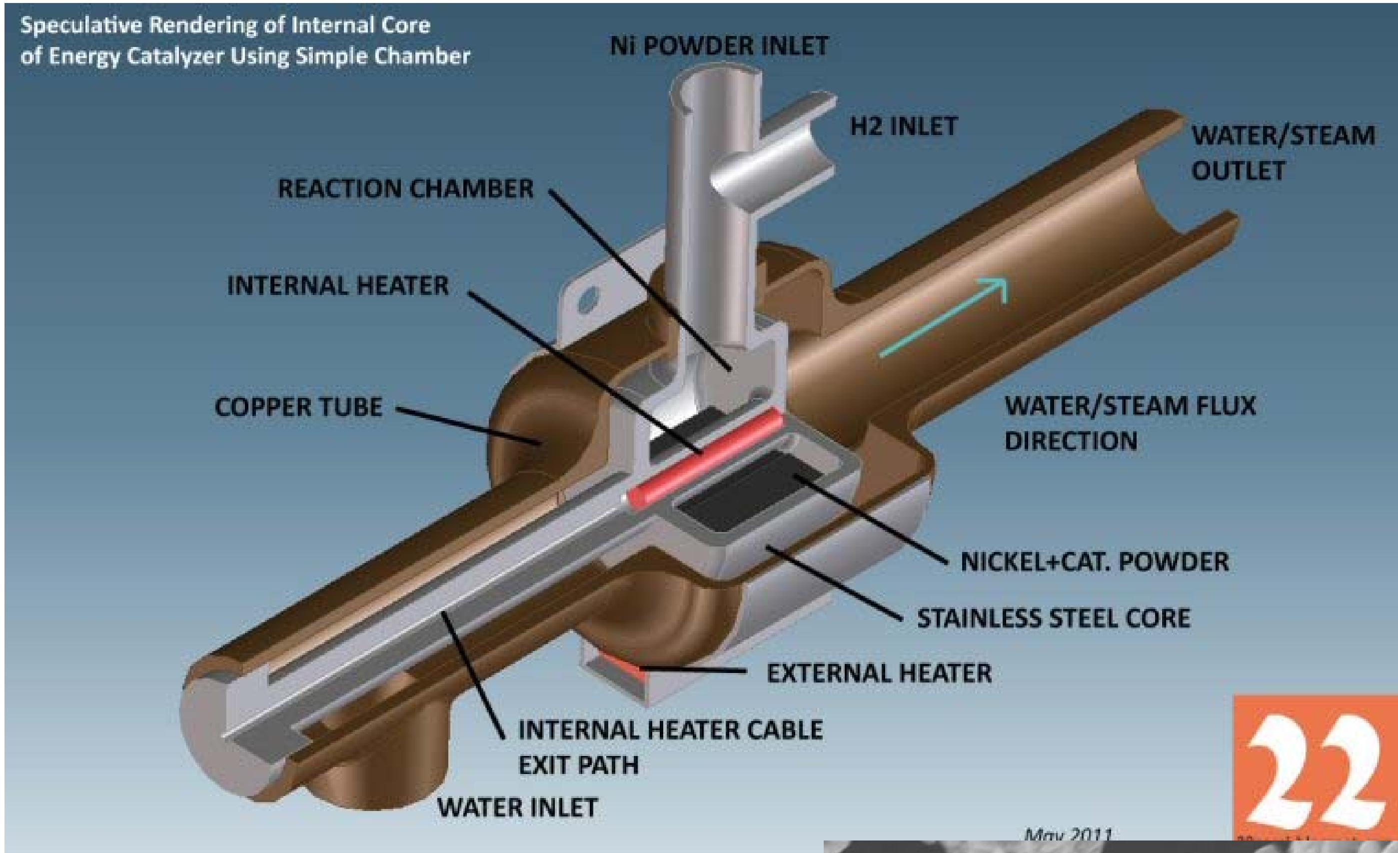
К 2015 году совокупная мощность отечественных фотоэлектрических установок может достичь 1 гигаватта. Это мощность 1 блока АЭС!

Нові безпечні генератори на основі E-cat технологвї Rossi

14 Jan 2011, *Bologna* – first demonstration of E-cat (Dr. *Andrea Rossi* , Prof. *Sergio Focardi)* Excepted nuclear reaction $_{28}Ni^{A} + p \rightarrow _{29}Cu^{A+1} + \Delta E$

P_{in} = 1250 W, P_{out} = 15-20 kW (t_{total} =18 h), $\Delta H_2 \approx 0.4$ gram




Speculative Rendering of Internal Core
of Energy Catalyzer Using Simple Chamber
Ni POWDER INLET
H2 INLET
WATER/STEAM
OUTLET
REACTION CHAMBER
INTERNAL HEATER
COPPER TUBE
WATER/STEAM FLUX
DIRECTION
NICKEL+CAT. POWDER
STAINLESS STEEL CORE
EXTERNAL HEATER
INTERNAL HEATER CABLE
EXIT PATH
WATER INLET
22
May 2011

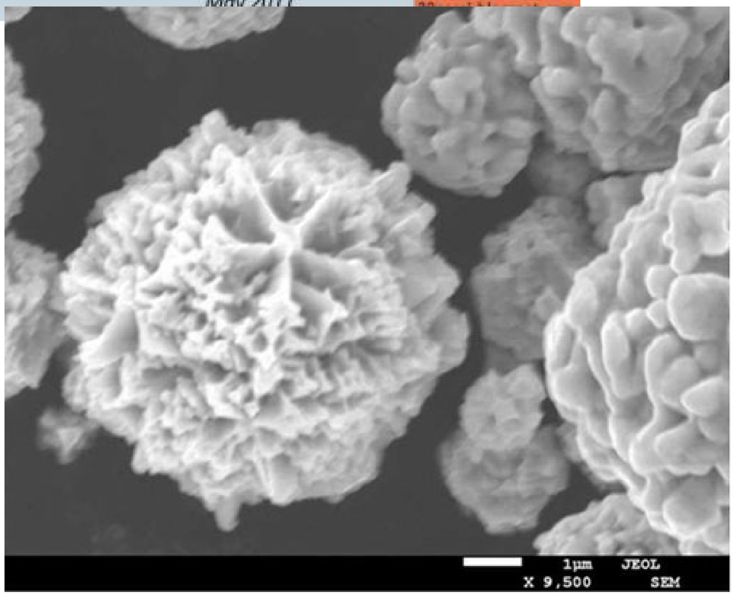

1μm JEOL
X 9,500 SEM

Figure showing the chimney with the black outlet tubing, the thermocouple holder and on the top, the steam exhaust valve.

IL NUOVO CIMENTO VOL. 107 A, N. 1 Gennaio 1994
NOTE BREVI

Anomalous Heat Production in Ni-H Systems.

S. FOCARDI ([1]), R. HABEL ([2]) and F. PIANTELLI ([3])

([1]) *Dipartimento di Fisica dell'Università - Bologna*
INFN, Sezione di Bologna - Bologna
([2]) *Istituto di Fisica, Facoltà di Medicina dell'Università - Cagliari*
INFN, Sezione di Cagliari - Cagliari
([3]) *Dipartimento di Fisica dell'Università - Siena*
IMO Siena and INFM, Sezione di Siena - Siena

(ricevuto il 3 Gennaio 1994; approvato il 12 Gennaio 1994)

Summary. — Evidence for a 50 W anomalous heat production in a hydrogen-loaded nickel rod is reported.

PACS 25.70.Jj – Fusion and fusion-fission reactions.

1. – Introduction.

Since the first claim from Fleischmann and Pons [1] for an anomalous productior of heat obtained during an electrochemical experiment, a great number of ex- periments has been devised and performed, in order to confirm or disprove the effect

In our opinion, till now, none of the groups involved in these experiments has reached a strong evidence for a consistent anomalous production of heat in a reproducible and controlled way.

At the end of 1989 one of us (FP), in an experiment of low-temperature calorimetry (about 200 K) on deuterated organic compounds in hydrogen atmosphere suspected an irregular balance of the heat involved.

After several discussions which took place in the following months, we reachec the conclusion that the probable responsible for the observed anomaly could have been the nickel support on which the organic sample had been deposited.

In order to investigate the process in detail, we devised a suitable experiment After some preliminary tests, the final apparatus which will be described below was assembled at the end of 1992 at the Physics Department of Siena University.

IL NUOVO CIMENTO VOL. 111 A, N. 11 Novembre 1998

Large excess heat production in Ni-H systems

S. FOCARDI([1]), V. GABBANI([2]), V. MONTALBANO([2]), F. PIANTELLI([2]) and S. VERONESI([2])

([1]) *Dipartimento di Fisica, Università di Bologna e INFN Sezione di Bologna - Bologna, Italy*
([2]) *Dipartimento di Fisica, Università di Siena e Centro IMO - Siena, Italy*

(ricevuto il 9 Marzo 1996; revisionato il 16 Settembre 1996; approvato il 30 Giugno 1998)

Summary. — Evidence of a large heat excess produced in Ni-H systems and details of the calorimetric measurements are reported in this paper. Two cells which ran for long periods (about 300 days) produced an energy excess of 600 MJ and 900 MJ, respectively.

PACS 25.70.Ji – Fusion and fusion-fission reactions.

1. – Introduction

In a previous paper [1] some of us reported on the existence of an anomalous heat production observed in hydrogen-loaded nickel rods. The phenomenon occurs when a cell containing a nickel rod is maintained at temperatures above a critical value and is filled with gaseous H_2 at subatmospheric pressures.

A constant input power was used to raise and keep the cell temperature constant at its working value (corresponding to about 700 K for the Ni rod). It was possible to induce an increase of the sample temperature from its working value to about 820 K. This anomalous equilibrium condition will be referred in the following as *excited state*. The system was able to remain in the *excited state* for several months.

The experimental cell described in ref. [1] was successively modified and also a new cell was built with an improvement which allows the measurement and the monitoring of the external surface temperature.

29 March 2011 P_{in} = 300 W; P_{out} = 4.39 kW, Q_{total}=25 kWh (Δt =6 h)

Prof. Sven Kullander - *Uppsala Univ.,Chair of Energy Committee of Swedish Royal Acad. Of Science*

Prof. Hanno Essen - *Swedish Royal Inst. of Technology, Cheir of Swedish Skeptics Society*.

Startup. Prior to startup, the hydrogen bottle with a nominal pressure of 160 bars was connected for a short moment to the device to pressurize the fuel container to about 25 bars. The air of atmospheric pressure was remaining in the container as a small impurity. The amount of hydrogen with the assumed container volume of 50 cm^3 is 0.11 grams of hydrogen.

During 6 h were produced about Q_{total}=25 kWh of thermal energy:

P_{in} = 300 W, P_{out} = 4.4 kW (Δt =6 h)

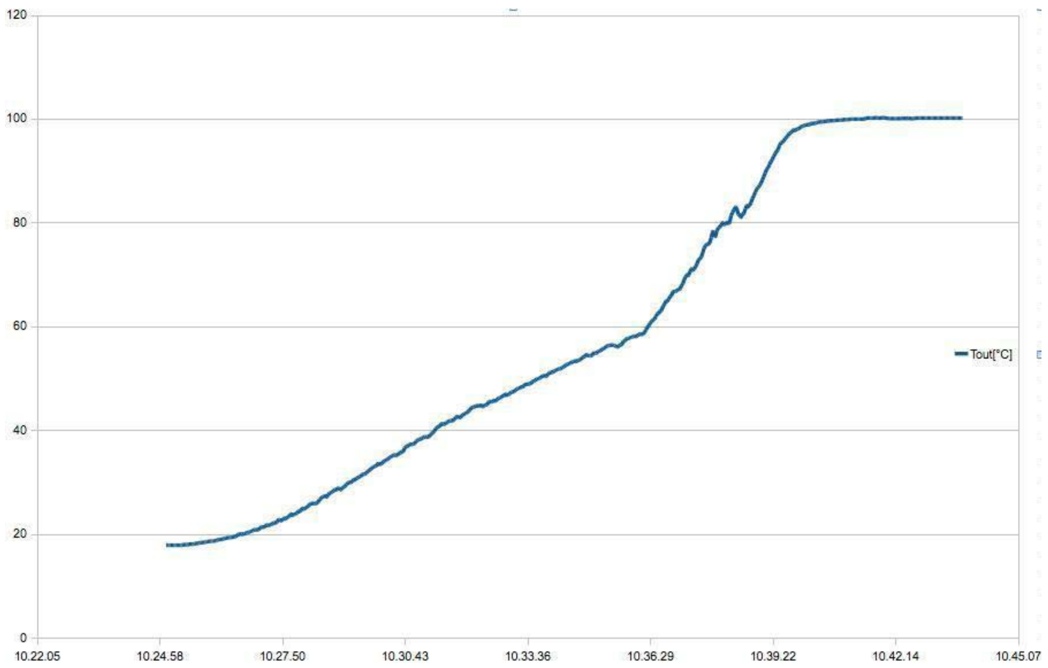


Figure. The evolution of temperature in Celsius degrees versus the time

Figure with Andrea Rossi preparing the insulation of the chimney together with Sven Kullander (left) and Hanno Essen (right)

Left to right, Hanno Essen, Andrea Rossi, Carlo Leonardi and Sergio Focardi

Figure 9 showing from left to right, Hanno Essén, Sven Kullander, Giuseppe Levi, David Bianchini and Andrea Rossi. (Photo: Sven Kullander).

Figure 10. David Bianchini, Andrea Rossi holding the mini ECAT and Giuseppe Levi. (Photo: Sven Kullander).

$$Ni^{58}(68\%) + p \rightarrow Cu^{59}(\tau = 82s) \rightarrow Ni^{59}(\tau = 76000y) + \beta^{+} + \nu; \qquad 1$$

$$Ni^{59} + p \rightarrow Cu^{60}(\tau = 23.7m) \rightarrow \begin{cases} Ni^{60} + \beta^{+} + \nu \ (93\%) \\ Cu^{60} + \beta^{-}(EC) \rightarrow Ni^{60} + \nu \ (7\%) \end{cases} \qquad 2$$

$$Ni^{60}(26.2\%) + p \rightarrow Cu^{61}(3.3h) \rightarrow \begin{cases} Ni^{61} + \beta^{+} + \nu \ (60\%) \\ Cu^{61} + \beta^{-}(EC) \rightarrow Ni^{61} + \nu \ (40\%) \end{cases} \qquad 3$$

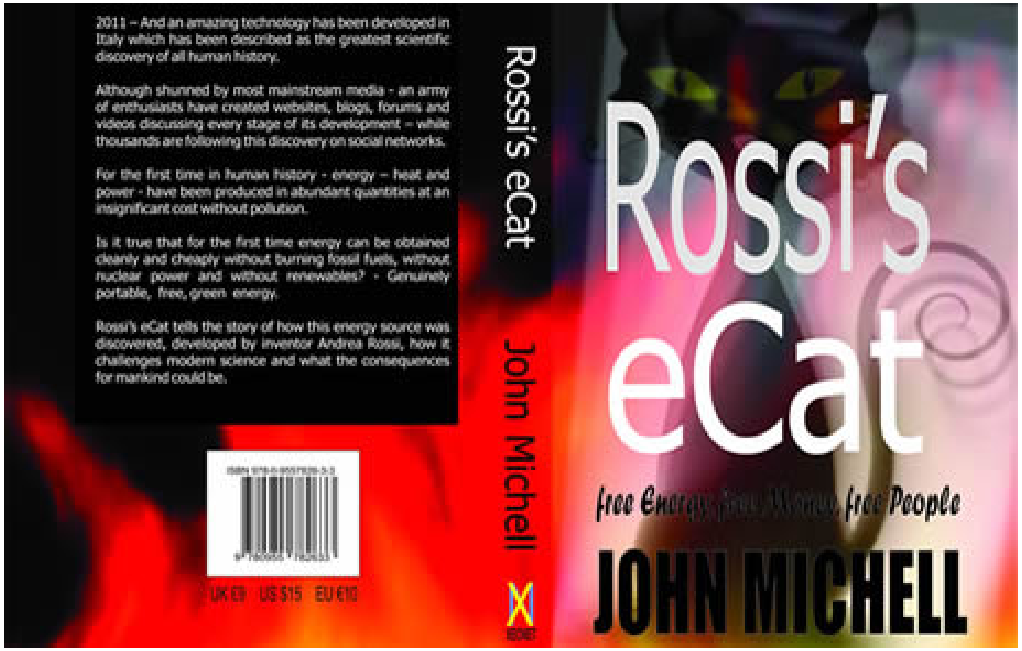
$$Ni^{61}(1.14\%) + p \rightarrow Cu^{62}(9.7m) \rightarrow Ni^{62} + \beta^{+} + \nu \qquad 4$$

$$Ni^{62}(3.63\%) + p \rightarrow Cu^{63*} + 6{,}12MeV \rightarrow \begin{cases} Cu^{63} + \gamma,\ \eta_{Cu^{63}} = 69\% \\ Cu^{63*} + \beta^{-}(EC) \rightarrow Ni^{63}(100y) + \nu (?) \end{cases} \qquad 5$$

$$Ni^{63} + p \rightarrow Cu^{64}(12.7h) \rightarrow \begin{cases} Cu^{64} + \beta^{-}(EC) = Ni^{64} + \nu \ \ (43\%) \\ Zn^{64} + \beta^{-} + \tilde{\nu} \ \ (39\%) \\ Ni^{64} + \beta^{+} + \nu \ \ (18\%) \end{cases} \qquad 6$$

$$Ni^{64}(0.926\%) + p \rightarrow Cu^{65},\ \eta_{Cu^{65}} = 31\% \qquad 7$$

$$Natural\ isotopic\ ratio: \eta_{Cu^{63}} / \eta_{Cu^{65}} \approx 2.2;\ In\ 6\ hours: \eta_{Cu^{63}} / \eta_{Cu^{65}} \approx 1.6$$



September 2011

Rossi: gain 600%, T_{out} ≈100-102 C

Cooperation–**National Instruments** Co (Creator of ITER's control systems!)

Defkalion Green Tech: gain 2500%
T_{out} ≈ 200-300C

Jan 2012 – sold 14 devices to a military customer and another one to a non-military customer.

The plan for 2013 – Rossi wants to put 1000 000 of 10-20kW devices on the market to be able to push the price below 1ct/kWh.
Now the prices (USA) are:
by gas – 4 ct/kWh,
by coal – 5 ct/kWh

100 g Ni+H cartridge/0.5 year (price - $10)!!!

Possible price of e-Cat (Rossi,Dec 2011):

$500 (at 10 kW) for "folk"; $1500/kW for industry

Great October Energetic Revolution

28 Oct 2011 Presentation of Great E-cat:
107 modules x (3 E-cat reactors in each) $P_{max} \approx 1$ MW

Duration of the presentation t=5.5 h, P_{exp} ≈ 0.5 MW

E_{in}=300 kWh, E_{out}=479 kWh *5.5=2635 kWh ⇔ 105 *liters of oil*!

DIPARTIMENTO PER L'IMPRESA E L'INTERNAZIONALIZZAZIONE

DIREZIONE GENERALE LOTTA ALLA CONTRAFFAZIONE
UFFICIO ITALIANO BREVETTI E MARCHI

Visualizza Scheda (Domanda: MI2008A000629 - Tipologia: Invenzioni)

N.B. *Non tutte le schede riportano la medesima struttura poichè essa è strettamente correlata alla tipologia trattata.*
Dati aggiornati al **24 gennaio 2012**

Visualizza Info

Torna alla lista dei risultati (tipologia Invenzioni) | Stampa la domanda

Inserisci questa scheda - relativa alla domanda n. MI2008A000629 - nell'elenco personalizzato

Data Deposito	N. Brevetto	Data Brevetto
09 aprile 2008	**0001387256**	**06 aprile 2011**
Stato Domanda	Anticipata accessibilità	Data di Pubblicazione
rilasciata	**no**	**10 ottobre 2009**

Titolo
processo ed apparecchiatura per ottenere reazioni esotermiche, in particolare da nickel ed idrogeno.

Titolare
PASCUCCI MADDALENA | ROMA | (RM) |

Inventori
ROSSI ANDREA

Domicilio elettivo
STUDIO PROF. FRANCO CICOGNA

Indirizzo
VIA VISCONTI DI MODRONE 14/A - 20122 MILANO (MI)

Centro raccolta colture microrganismi
-

Classi
Codice Classi
01M

Priorità

Nazione	Numero domanda	Data domanda
	-	-

CCP/CCPF

Nel database non sono state trovate domande di CCP o CCPF

Conversione della domanda

Nel database non risultano pervenute domande di trasformazione o di deposito contemporaneo.

Annotazioni

Nel database non sono state trovate annotazioni per questa domanda

Trascrizioni

Trascrizione Numero: **1**

Numero Domanda	Data Deposito	Stato Domanda	Tipo di atto	Tipo di trascrizione
BO2010E000076	**22 luglio 2010**	**accolta**	**Scrittura privata eccezionalmente non autenticata**	**licenza esclusiva**
Atto	Data Registrazione	Codice	Provincia	
8556	**01 ottobre 2010**	-	**BO**	

Nome e indirizzo del Presentatore
EFA SRL |
VIA MARSILI 4 | BOLOGNA | (BO) |
Cedenti
PASCUCCI MADDALENA | VIA EZIO 24 | 00100 | ROMA | (RM) |
Cessionari
EFA SRL | VIA MARSILI 4 | 40100 | BOLOGNA | (BO) |
Note
-

Elenco personalizzato (nessuna domanda selezionata)

Titolare **PASCUCCI MADDALENA**

Inventor **ROSSI ANDREA**

US 20140326711A1

(19) **United States**

(12) **Patent Application Publication**

Rossi

(10) **Pub. No.: US 2014/0326711 A1**

(43) **Pub. Date: Nov. 6, 2014**

(54) **DEVICES AND METHODS FOR HEAT GENERATION**

(71) Applicant: **Industrial Heat, Inc.**, Raleigh, NC (US)

(72) Inventor: **Andrea Rossi**, Miami Beach, FL (US)

(73) Assignee: **LEONARDO CORPORATION**, Miami Beach, FL (US)

(21) Appl. No.: **14/262,740**

(22) Filed: **Apr. 26, 2014**

Related U.S. Application Data

(60) Provisional application No. 61/818,553, filed on May 2, 2013, provisional application No. 61/819,058, filed on May 3, 2013, provisional application No. 61/821,914, filed on May 10, 2013.

Publication Classification

(51) **Int. Cl.**
H05B 1/02 (2006.01)
G21B 3/00 (2006.01)

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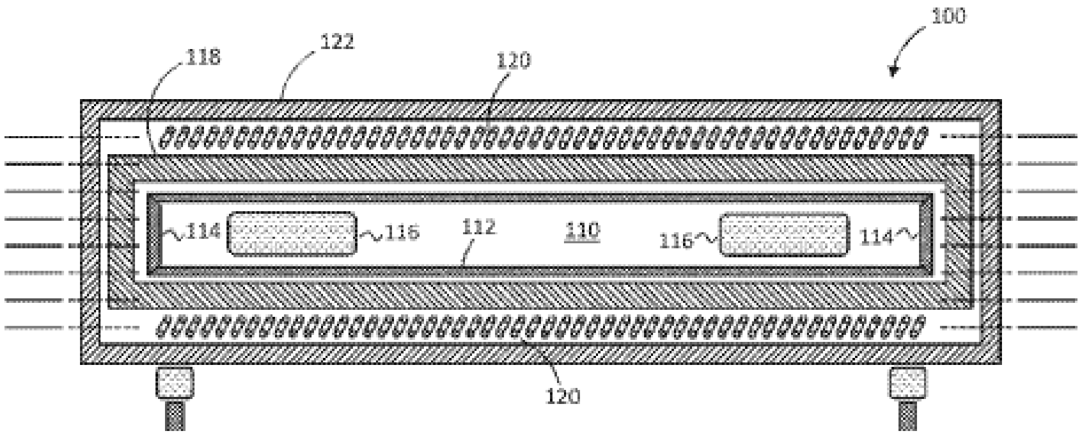
USPC **219/439**

(57) **ABSTRACT**

A reactor device includes a sealed vessel defining an interior, a fuel material within the interior of the vessel, and a heating element proximal the vessel. The fuel material may be a solid including nickel and hydrogen. The sealed vessel may be sealed against gas ingress or egress and may contain no more than a trace amount of gaseous hydrogen. The sealed vessel is heated with an input amount of energy without ingress or egress of material into or out of the sealed vessel. An output amount of thermal energy exceeding the input amount of energy is received from the sealed vessel. The fuel material has a specific energy greater than that of any chemical reaction based energy source.



FINANCIAL ASSISTANCE
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OPEN INNOVATIVE DEVELOPMENT IN ENERGY-RELATED APPLIED SCIENCE (OPEN IDEAS)

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1. Mechanical	2. Thermal	3. Chemical	4. Electrical	5. Radiant	6. Nuclear	
1.1 compressors, transmissions, hydraulics	1.2 turbines/engines, acoustic cooling, geothermal, tribology	1.3 pressure swing sorption, osmotic pumps	1.4 electromagnetic generators, flywheels, CAES	1.5 triboluminescence, photomechanical devices	1.6 centrifugal isotope enrichment, fusion ion propulsion	1. Mechanical
	2.2 heat pipes, thermal storage, heat exchangers, phase change materials	2.3 combustors, chemical cooling, thermochemical processing, desalinization	2.4 solid-state heat engines (thermionic or thermoelectric), HVAC, heat pumps	2.5 concentrated solar thermal, selective emitters, optical heat pumps	2.6 thermonuclear fusion, radioisotope thermoelectrics	2. Thermal
		3.3 gas-to-liquid technology, separations, extractions	3.4 electrochemical devices/storage, fuel cells, electrochemical processing	3.5 chemilumin-escence, photochemical reactors, biofuels, solar fuels	3.6 chemonuclear reactors, low-energy nuclear reactions, nuclear fuel chemistry	3. Chemical
			4.4 smart grid, SMES, power electronics	4.5 light emitting diodes, lasers, photovoltaics	4.6 particle accelerators or accelerator-driven systems, betavoltaics	4. Electrical
				5.5 spectral splitters, concentrators, optically-pumped lasers, daylighting	5.6 optoelectric nuclear battery, radioisotope thermophotovolta-ics, inertial confinement fusion	5. Radiant
					6.6 nuclear fuel cycles, hybrid fission-fusion reactors	6. Nuclear

3.6. Chemonuclear reactions, low-energy nuclear reactions, nuclear fuel chemistry

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THEORETICAL AND MATHEMATICAL PHYSICS

Correlated States of Interacting Particles and Problems of the Coulomb Barrier Transparency at Low Energies in Nonstationary Systems

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Abstract—Premises for the formation of a correlated coherent state of particles in nonstationary quantum systems are considered. The relation between the correlation factor of particles and the probability of their passage through the potential barrier (including that in nuclear reactions) is analyzed. The optimal regime for parametric excitation of a harmonic oscillator is found, in which the asymptotic formation of the correlated state of particles takes place, the dispersion of their coordinates increases manifold, and the barrier transparency becomes many orders of magnitude higher at a low energy of interacting particles.

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INTRODUCTION

It is well known that the tunnel effect plays an extremely important role in atomic and nuclear physics. This effect underlies the operation of most instru-

mately, the total tunneling probability for a superposition of states is the sum of very small values of tunneling probabilities for each of these initial states.

However, for correlated states, the situation is com-

ПОВЕРХНОСТЬ. РЕНТГЕНОВСКИЕ, СИНХРОТРОННЫЕ И НЕЙТРОННЫЕ ИССЛЕДОВАНИЯ, 2010, № 4, с. 105–112

УДК 530.145:537.534:539.2:539.1.04:548.0

ФОРМИРОВАНИЕ И ИСПОЛЬЗОВАНИЕ КОГЕРЕНТНЫХ КОРРЕЛИРОВАННЫХ СОСТОЯНИЙ ЗАРЯЖЕННЫХ ЧАСТИЦ В ФИЗИКЕ КАНАЛИРОВАНИЯ В КРИСТАЛЛАХ

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В работе на примере эффекта каналирования заряженных частиц в кристаллах рассмотрены особенности проявления корреляционных эффектов в квантовых системах. Изучена возможность формирования когерентного коррелированного состояния частиц за счет деформации параболической потенциальной ямы, которая определяет движение заряженных частиц в пространстве между кристаллическими плоскостями при каналировании. Показано, что такая деформация может быть осуществлена при неоднородном (относительно продольной координаты) возбуждении атомов, образующих стенки канала. Путем численного моделирования показано, что каналирование частиц, находящихся в когерентном коррелированном состоянии, приводит к резкому возрастанию вероятности туннельного эффекта и возможности проникновения каналируемых частиц в пространство под барьером.

ВВЕДЕНИЕ

Процесс каналирования заряженных частиц в кристаллических каналах является одной из наиболее успешных реализаций управляемого квантового объекта, сочетающего достоинства квантовой системы с дискретными уровнями энергии и преимущества релятивистских объектов с возможностью очень большого изменения частотно-угловых характеристик

коррелированные состояния (ННС), для которых соотношение неопределенностей, связывающее дисперсии σ_q и σ_p координаты q и одноименной компоненты импульса частицы p имеет вид соотношения Гейзенберга

$$\sigma_p\sigma_q \geq \hbar^2/4, \quad \sigma_p = \langle (p - \langle p \rangle)^2 \rangle, \quad \sigma_q = \langle (q - \langle q \rangle)^2 \rangle. \quad (1)$$

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NUCLEI, PARTICLES, FIELDS, GRAVITATION, AND ASTROPHYSICS

Formation and Application of Correlated States in Nonstationary Systems at Low Energies of Interacting Particles

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Abstract—We consider prerequisites and investigate some optimal methods for the formation of a correlated coherent state of interacting particles in nonstationary systems. We study the influence of the degree of particle correlation on the probability of their passage through the Coulomb barrier for the realization of nuclear reactions at low energies. For such processes, the tunneling probability and, accordingly, the probability of nuclear reactions can grow by many orders of magnitude (in particular, the barrier transparency increases from $D_{r=0} \approx 10^{-42}$ for an uncorrelated state to $D_{|r|=0.98} \approx 0.1$ at a correlation coefficient $|r| \approx 0.98$). The formation of a correlated particle state is considered in detail for different types of monotonic decrease in the frequency of a harmonic oscillator with the particle located in its parabolic field. For the first time, we have considered the peculiarities and investigated the efficiency of the creation of a correlated state under a periodic action on a harmonic oscillator. This method is shown to lead to rapid formation of a strongly correlated particle state that provides an almost complete clearing of the potential barrier even for a narrow range of oscillator frequency variations.

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1. INTRODUCTION

rium or tritium under terrestrial conditions virtually unrealistic [1, 2].

ПОВЕРХНОСТЬ. РЕНТГЕНОВСКИЕ, СИНХРОТРОННЫЕ И НЕЙТРОННЫЕ ИССЛЕДОВАНИЯ, 2012, № 4, с. 1–6

УДК 530.145;537.534;539.2;539.1.04;548.0

ПОДБАРЬЕРНОЕ ВЗАИМОДЕЙСТВИЕ КАНАЛИРУЕМЫХ ЧАСТИЦ ПРИ АВТОМОДЕЛЬНОМ ВОЗБУЖДЕНИИ КОРРЕЛИРОВАННЫХ СОСТОЯНИЙ В ПЕРИОДИЧЕСКИ ДЕФОРМИРОВАННОМ КРИСТАЛЛЕ

© 2012 г. В. И. Высоцкий[1, 2], С. В. Адаменко[2], М. В. Высоцкий[1]

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Показано, что использование периодической модуляции параметров параболической потенциальной ямы (в случае каналирования заряженных частиц в кристаллах – периодической пространственной модуляции высоты стенок потенциальной ямы в кристаллическом канале) приводит к формированию когерентного каналированного состояния частиц, находящихся в этой яме. Формирование такого состояния изменяет процесс взаимодействия этих частиц с ядрами и на много порядков увеличивает прозрачность барьера. Для каналирования такой режим может быть обеспечен, например, при наличии продольной бегущей вдоль оси канала акустической волны, изменяющей расстояние между ядрами и, соответственно, модулирующей высоту стенок канала.

ВВЕДЕНИЕ

Традиционное рассмотрение процесса каналирования частиц в кристаллах основано на предположении о взаимной независимости квантовых состояний частицы на каждом из уровней попе-

наты $\sigma_q \equiv (\delta q)^2 = \langle (q - \overline{q})^2 \rangle$ и импульса $\sigma_{p_q} \equiv (\delta p_q)^2 = \langle (p_q - \overline{p}_q)^2 \rangle$

$$\delta q \delta p_q \geq \hbar / 2\sqrt{1 - r^2}, \quad (1)$$

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ATOMS, MOLECULES, OPTICS

The Formation of Correlated States and the Increase in Barrier Transparency at a Low Particle Energy in Nonstationary Systems with Damping and Fluctuations

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bstract—We consider peculiarities in the formation of a coherent correlated state (CCS) of a particle i
eriodically modulated harmonic oscillator with damping for various types of stochastic perturbation. I
hown that in the absence of stochastic perturbation, an optimal relation exists between the damping para
ter (damping coefficient) and the modulation depth, for which the "extrinsic" characteristics of the osci
or (amplitudes of "classical" oscillation and the momentum of a particle) remain unchanged, while the c
elation coefficient rapidly increases from $|r| = 0$ to $|r|_{max} \approx 1$; this corresponds to a completely correla
oherent state. Under nonoptimal conditions, the formation of the CCS with a simultaneous increase in
accompanied by damping or excitation of the oscillator. It is shown that for a certain relation between
amping coefficient and the modulation depth, the presence of a stochastic external force acting on the n
tationary oscillator does not prevent the formation of a CCS with $|r|_{max} \longrightarrow 1$. A fundamentally differ

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Acceleration of low energy nuclear reactions by formation of correlated states of interacting particles in dynamical systems

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ABSTRACT

In this work the most universal mechanism of essential acceleration of low energy nuclear reactions on the basis of correlated states of interacting particles is considered. This mechanism provides a giant increase of barrier penetrability under critical conditions (low energy, high barrier), where the effectiveness of "ordinary" tunneling effects is negligibly small, and can be applied to different experiments. The physical reason of an increased barrier penetrability in correlated states is connected to the modified uncertainty relation $\sigma_p \sigma_q \geqslant \hbar^2/4\left(1 - r_{pq}^2\right)$ for correlated states and to the increase in momentum σ_p and position σ_q variances with increasing of correlation coefficient r_{pq}. We have considered preconditions and methods of formation of correlated coherent states of interacting nuclei in non-stationary dynamical systems. It was shown that in real nuclear-physical systems at $r_{pq}^2 \to 1$ very sharp growth (up to a factor of 10^{30}–10^{100} and more!) of Coulomb barrier penetrability at very low energy of interacting particles is possible. Several successful low-energy correlated-induced fusion experiments are discussed.

1. Introduction

many different disconnected experiments have been carried out, where the nuclear synthesis proceeds at a low energy and under

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THE EUROPEAN PHYSICAL JOURNAL A

Regular Article – Theoretical Physics

Coherent correlated states and low-energy nuclear reactions in non stationary systems

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Abstract. In this paper the universal mechanism of optimization of low-energy nuclear reactions on the basis of coherent correlated states of interacting particles is discussed. The formation of these states is the result of the special nonstationary low-energy action to any one of these interacting particles. We have considered the peculiarities and investigated the efficiency of the creation of a correlated state under monotonous or periodic action on the particle that is situated in the parabolic potential. This method is shown to lead to the rapid formation of a strongly correlated particle state that provides an almost complete clearing of the potential barrier even for a narrow range of oscillator frequency variations. The successful low-energy fusion experiment based on the use of correlated states of interacting particles at laser irradiation is discussed.

1 Introduction

It is well known that the total probability for nuclear reac-

Together with these "classical" and extremely expensive thermonuclear studies, whose efficiency is not proportional to the undertaken efforts and the financial ex-

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Correlated States and Transparency of a Barrier for Low-Energy Particles at Monotonic Deformation of a Potential Well with Dissipation and a Stochastic Force

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Abstract—The features of the formation of correlated coherent states of a particle in a parabolic potential well at its monotonic deformation (expansion or compression) in finite limits have been considered in the presence of dissipation and a stochastic force. It has been shown that, in both deformation regimes, a correlated coherent state is rapidly formed with a large correlation coefficient $|r| \longrightarrow 1$, which corresponds at a low energy of the particle to a very significant (by a factor of 10^{50}–10^{100} or larger) increase in the transparency of the potential barrier at its interaction with atoms (nuclei) forming the "walls" of the potential well or other atoms located in the same well. The efficiency of the formation of correlated coherent states, as well as $|r|$, increases with an increase in the deformation interval and with a decrease in the deformation time. The pres-