
Physics Education

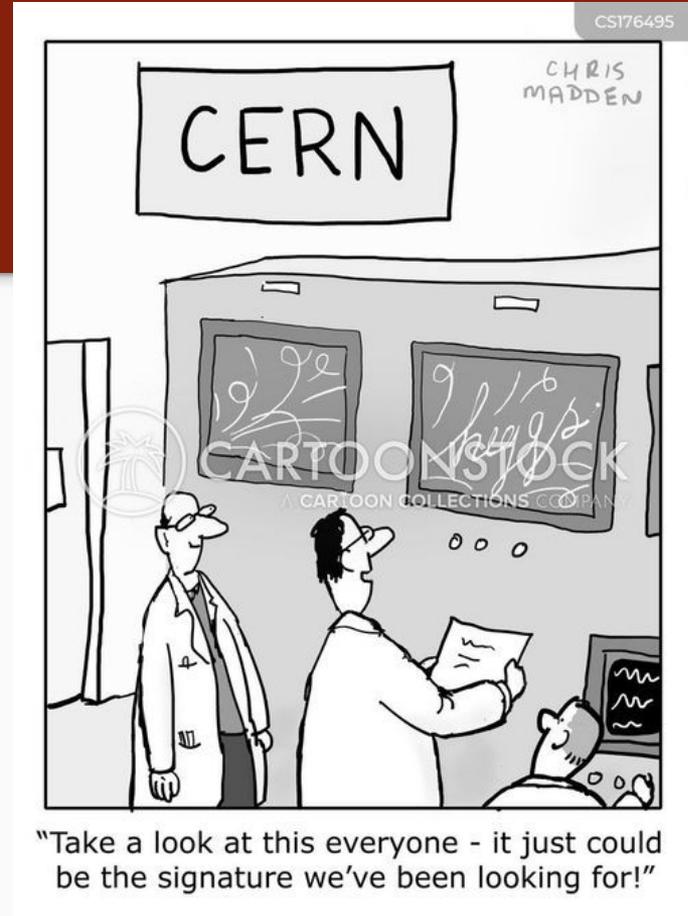
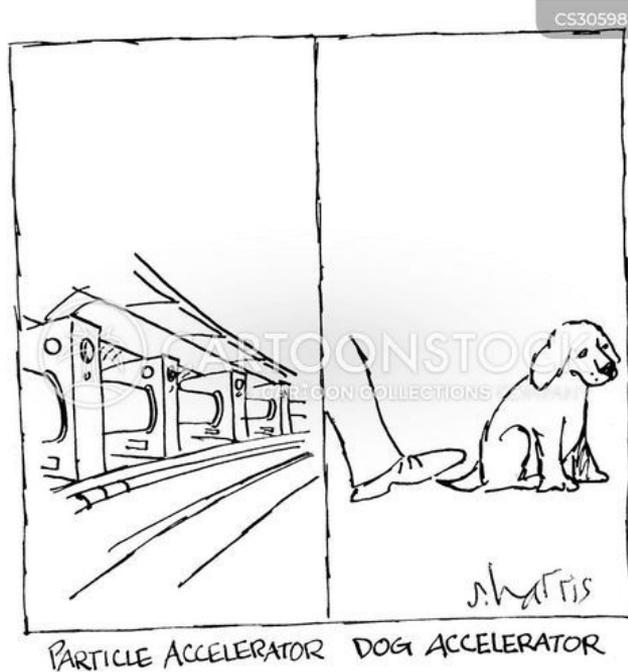
Laboratory

Lecture 24

Content Knowledge for Modern Physics

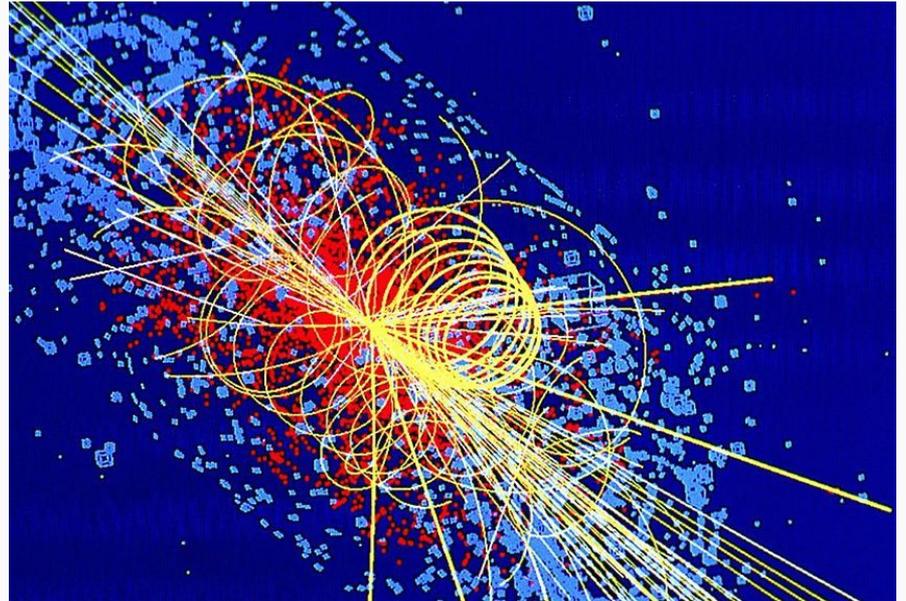
Francesco Longo • 19/12/2025

Particle Physics



PCK for modern Physics

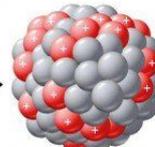
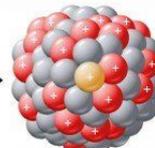
- To the infinitesimal world ...
 - Radioactivity
 - Nuclear Physics
 - Particle Physics



PCK for modern Physics

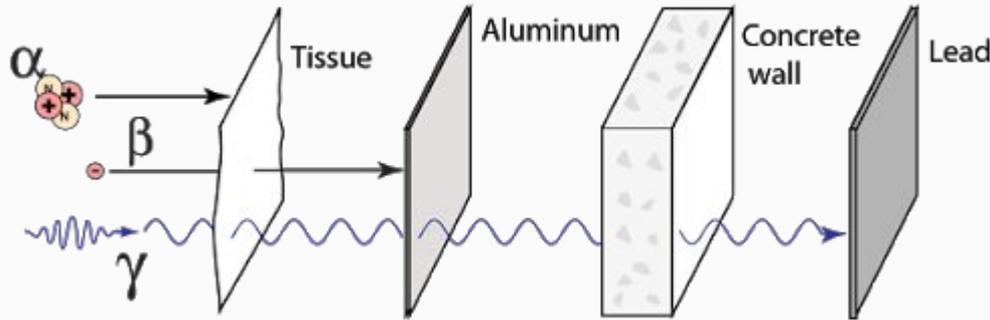
- Radioactivity



Decay Type	Generic Equation	Model		
Alpha decay	$\frac{A}{Z}X \rightarrow \frac{A-4}{Z-2}X' + \frac{4}{2}\alpha$			
Beta decay	$\frac{A}{Z}X \rightarrow \frac{A}{Z+1}X' + \frac{0}{-1}\beta$			
Gamma emission	$\frac{A}{Z}X^* \xrightarrow{\text{Relaxation}} \frac{A}{Z}X' + \frac{0}{0}\gamma$			

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- Radioactivity



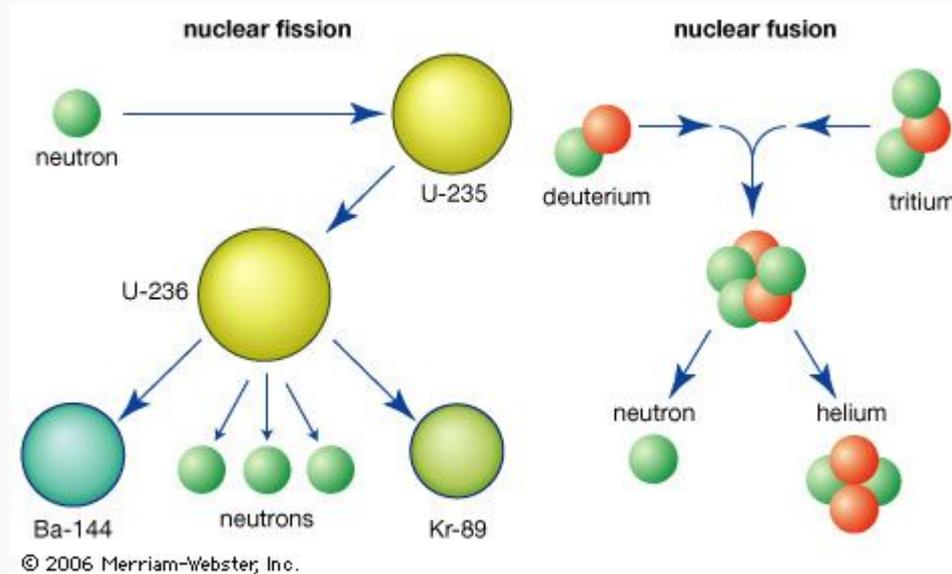
$$N(t) = N_0 \left(\frac{1}{2} \right)^{\frac{t}{t_{1/2}}}$$

$$N(t) = N_0 e^{-\frac{t}{\tau}}$$

$$N(t) = N_0 e^{-\lambda t}$$

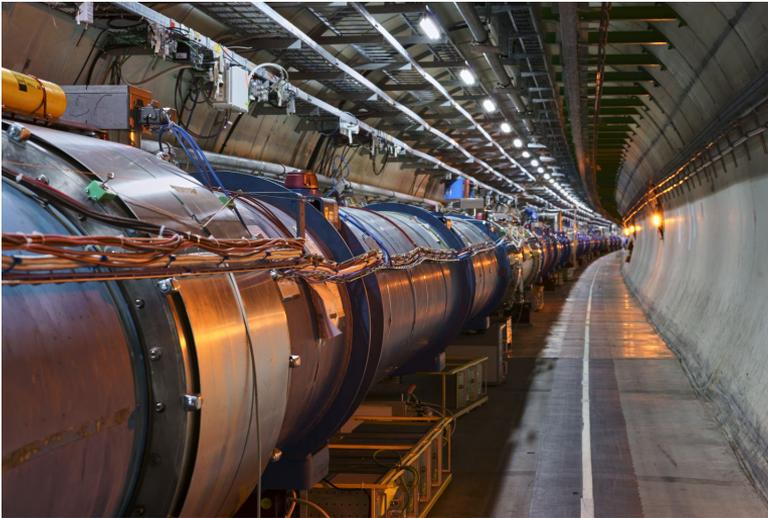
PCK for modern Physics

- Nuclear Energy



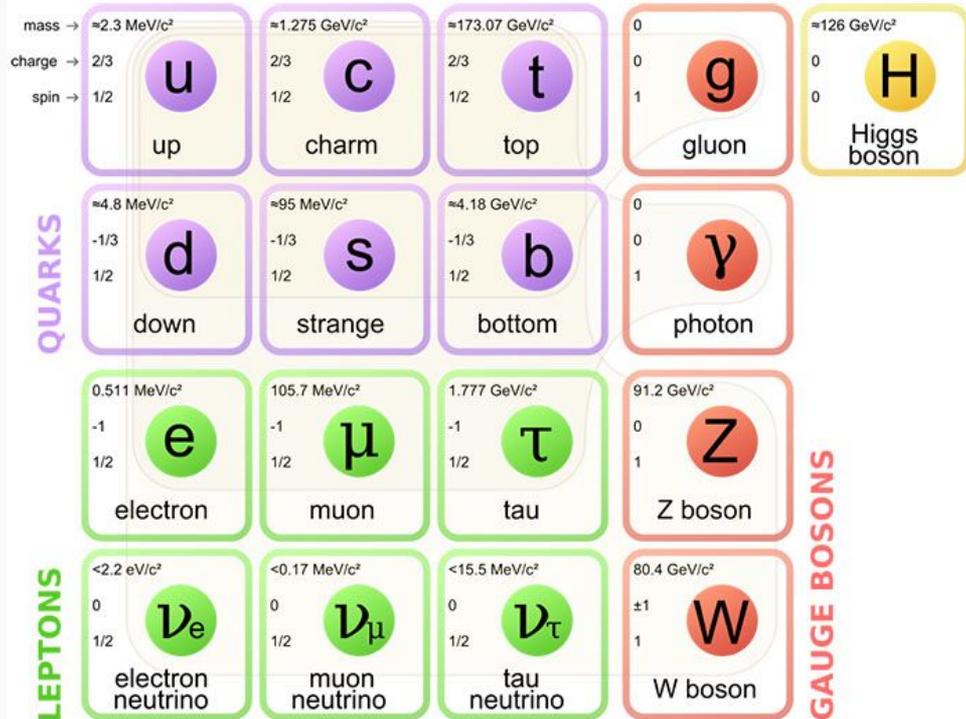
PCK for modern Physics

- The accelerators



PCK for modern Physics

- The particles ...



Materials ?

THE PARTICLE ADVENTURE
THE FUNDAMENTALS OF MATTER AND FORCE

Supported by the DOE and NSF

LANGUAGES MIRROR SITES

Android App Available now | Apple App Available now

An **award-winning** interactive tour of quarks, neutrinos, antimatter, extra dimensions, dark matter, accelerators and particle detectors from the **Particle Data Group** of **Lawrence Berkeley National Laboratory**.

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d u

THE STANDARD MODEL
The theory of fundamental particles and forces
GO!

HIGGS BOSON DISCOVERED: FIREWORKS ON THE 4TH OF JULY
GO!

ACCELERATORS AND PARTICLE DETECTORS
GO!

EXPLORING UNSOLVED MYSTERIES
GO!

PARTICLE DECAYS AND ANNIHILATIONS
GO!

CLASSROOM ACTIVITIES **CLICK HERE!**

<https://particleadventure.org/>

Materials ?

The image shows the homepage of the Contemporary Physics Education Project website. The header is blue with the logo on the left and navigation links (Home, About Us, Contact, Donate, Products and Resources) on the right. A green button labeled 'ORDER CPEP CHARTS' is also in the header. The main content area has a dark blue background with a grid of physics charts. The central text reads 'inspire physics pioneers.' Below this, a paragraph states: 'CPEP offers beautifully illustrated charts that present the current understanding of physics in areas ranging from quarks to the cosmos, incorporating recent discoveries such as the Higgs boson and gravitational waves.' At the bottom of the main area are two buttons: 'GET THE CHARTS' and 'RESOURCE OVERVIEW'.

Contemporary Physics Education Project

Home About Us Contact Donate Products and Resources

ORDER CPEP CHARTS

inspire physics pioneers.

Fusion

FUNDAMENTAL PARTICLES AND INTERACTIONS

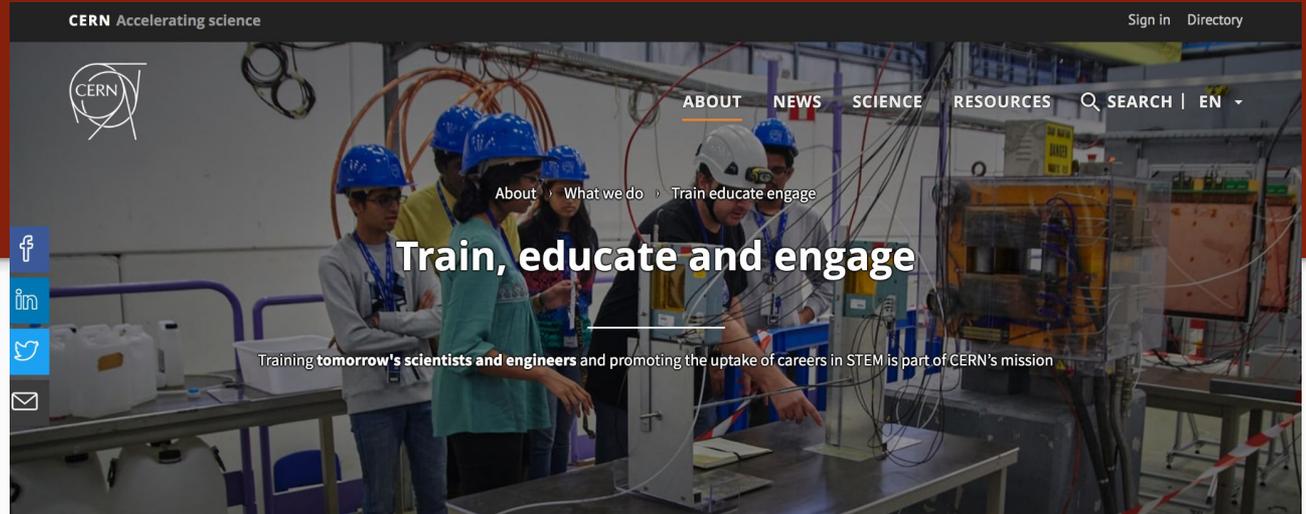
Nuclear Science

CPEP offers beautifully illustrated charts that present the current understanding of physics in areas ranging from quarks to the cosmos, incorporating recent discoveries such as the Higgs boson and gravitational waves.

GET THE CHARTS RESOURCE OVERVIEW

<https://www.cpepphysics.org/>

Materials ?



The founding Convention recognised the important role that CERN could play in training Europe's scientists and engineers. The Laboratory offers a unique environment for training – a rich and stimulating melting pot of people and ideas giving its young people an exceptional opportunity to hone their communication and analytical skills.

As a large accelerator laboratory, CERN relies on expertise in many engineering subjects, all of which feature in the recruitment and training programmes. There are opportunities for students in applied physics, engineering and computing to learn on the job at CERN and for technicians to train in fields at the cutting edge of technology. The comprehensive range of training schemes and fellowships attracts many talented young scientists and engineers to the Laboratory. Many go on to find careers in industry, where their experience of working in a high-tech, multi-national environment is highly valued.

Moreover, CERN's education and outreach programmes cover all ages from high-school students to university students. Specifically, CERN offers the tailor-made High-School Students Internship Programme several times per year and the Beamline for Schools Competition, challenging high-school students from around the world to propose an experiment to carry out at a real research laboratory. Indeed, of the 100 000 visitors who come to CERN each year, the majority are high-school students who also participate in a hands-on workshop in CERN's S'Cool LAB.

<https://home.cern/about/what-we-do/train-educate-engage>

Connection with Research facilities?

LINEE GENERALI E COMPETENZE

Al termine del percorso liceale lo studente avrà appreso i concetti fondamentali della fisica, le leggi e le teorie che li esplicitano, acquisendo consapevolezza del valore conoscitivo della disciplina e del nesso tra lo sviluppo della conoscenza fisica ed il contesto storico e filosofico in cui essa si è sviluppata.

In particolare, lo studente avrà acquisito le seguenti competenze: osservare e identificare fenomeni; formulare ipotesi esplicative utilizzando modelli, analogie e leggi; formalizzare un problema di fisica e applicare gli strumenti matematici e disciplinari rilevanti per la sua risoluzione; fare esperienza e rendere ragione del significato dei vari aspetti del metodo sperimentale, dove l'esperimento è inteso come interrogazione ragionata dei fenomeni naturali, scelta delle variabili significative, raccolta e analisi critica dei dati e dell'affidabilità di un processo di misura, costruzione e/o validazione di modelli; comprendere e valutare le scelte scientifiche e tecnologiche che interessano la società in cui vive.

La libertà, la competenza e la sensibilità dell'insegnante – che valuterà di volta in volta il percorso didattico più adeguato alla singola classe – svolgeranno un ruolo fondamentale nel trovare un raccordo con altri insegnamenti (in particolare con quelli di matematica, scienze, storia e filosofia) e nel promuovere collaborazioni tra la sua Istituzione scolastica e Università, enti di ricerca, musei della scienza e mondo del lavoro, soprattutto a vantaggio degli studenti degli ultimi due anni.

Visits to Museums?



museo della scienza interattivo e multimediale

IS Immaginario scientifico museo

in centrale S. science centre Trieste

Immaginario geografico Museo

Immaginario scientifico percorso

Immaginario didattico percorso

Immaginario archeologico percorso storico

contenuti digitali online

science centre Immaginario scientifico

Situato nella splendida baia di Giugosana, a ridosso del Parco di Miramare di Trieste, il Science Centre Immaginario Scientifico (IS) è un museo della scienza interattiva e multimediale. Il centro adotta originali tecniche espositive e innovative metodologie di animazione didattica che lo inseriscono nella tipologia dei cosiddetti "musei di nuova generazione" - ovvero i "science centre" di scuole anglosassoni - che rivoluzionano le modalità tipiche di un museo tradizionale: da luogo deputato alla conservazione ed esposizione di reperti e vecchi strumenti, il museo si trasforma in un luogo vivo, dove il visitatore interagisce con gli oggetti presentati e con gli ambienti museali.

Il Science Centre è anche uno spazio pubblico che propone percorsi, mostre, eventi e attività volte alla diffusione della cultura scientifica e tecnologica, con particolare attenzione per i grandi temi emergenti che coinvolgono scienza e società.

Tra i principali settori caratterizzano il Science Centre:



FENOMENA

Un ambiente socializzante che raccoglie la collezione di esibizioni hands-on ("partecipazioni interattive"), organizzata secondo specifici percorsi tematici. Oggetti da manipolare e con cui giocare per avvicinarsi in modo piacevole ai fenomeni naturali e scoprire le leggi fisiche che li governano.



KALEIDO

Uno spazio multimediale, nel quale immergersi in mostre tematiche sempre diverse: multivisioni ad alta definizione su maxischermi, ipertesti, allestimenti interattivi. Musiche suggestive danno vita a un'originale fusione tra contenuto scientifico e coinvolgimento emotivo.



COSMO

Un planetario a cupola rigida che invita a scoprire le meraviglie dei moti astrali: simulazione di albe e tramonti, le costellazioni e il movimento apparente delle stelle durante la notte e le stagioni, la posizione dei pianeti nella volta celeste.

modalità di accesso

Base
Science Centre Immaginario Scientifico
Via Miramare e Canale, 10
34100 Giugosana (Trieste)
Tel. 0431 224241 - 0431 224242
Email: info@immaginoscientifico.it
www: www.immaginoscientifico.it

Orario

dal gennaio a maggio

e da ottobre a dicembre

domenica 10.00-02.00

dal giugno a settembre:

estate e domenica 10.00-02.00

chiuso su prenotazione durante le settimane

dei "giorni a scuola"

Attività speciali

2020: 1 Aprile - 15 Aprile - 15 Maggio - 15

15 Agosto - 15 Ottobre - 15 Novembre - 30

dicembre

Quanto

ingresso familiare:

gratuito

ingresso familiare:

ingresso libero € 4,00

ingresso ridotto* € 2,00

ingresso scuola € 0,00

(accompagnati da genitori/grandi)

ingresso disabili:

ingresso libero € 3,00

ingresso ridotto** € 2,00

**per bambini da 6 a 12 anni,

adulti oltre 65 anni, con handicap



HOME SEDI COSA FACCIAMO SCUOLE CHI SIAMO CONTATTI   

SCIENCE CENTRE IMMAGINARIO SCIENTIFICO DI TRIESTE

MUSEO DELLA SCIENZA INTERATTIVO E SPERIMENTALE

L'Immaginario Scientifico di Trieste si trova nel **Magazzino 26 del Porto Vecchio**.

Dall'ottobre 2020 il museo della scienza interattivo e sperimentale occupa infatti una porzione del più grande magazzino del Porto Vecchio di Trieste, risalente al 1894, e recentemente ristrutturato. Al momento è possibile visitare metà degli spazi del nuovo Immaginario Scientifico, quella collocata al piano terra. Per poter conoscere il museo nella sua interezza bisognerà attendere la primavera del 2021.

Il nuovo Immaginario è caratterizzato da **spazi museali multimediali, immersivi e coinvolgenti**, con **apparati interattivi da toccare con mano**, per scoprire non solo i **fenomeni naturali** ma le applicazioni più **innovative** della scienza e le **attività di ricerca** degli enti del sistema scientifico di Trieste.

L'obiettivo è che ognuno, indipendentemente dall'età o dal livello di conoscenza scientifica, avvii un **processo di scoperta autonomo**, guidato dallo **stupore** e dalla **curiosità**, orientato ad acquisire **consapevolezza e cittadinanza scientifica**.

<https://www.immaginoscientifico.it/>

Connection with Research facilities?



Istituto Nazionale di Fisica Nucleare

INFN

UFFICIO COMUNICAZIONE

selezione e cerca

INFN HOME NEWS EVENTI MOSTRE MATERIALI AREA STAMPA RASSEGNA CONTATTI



IN PRIMO PIANO

26 MAGGIO, OPEN DAY AL GRAN SASSO

Domenica 26 maggio i Laboratori Nazionali del Gran Sasso dell'INFN ospitano l'undicesima edizione dell'Open Day, una giornata di scienza e gioco a cui sono attesi circa 2000 visitatori. Una parte di questi, circa 400, avranno la possibilità di visitare (previa prenotazione) le sale sperimentali sotterranee dei Laboratori che ospitano una quindicina di esperimenti costruiti per studiare alcuni degli aspetti più misteriosi ed affascinanti del cosmo. La manifestazione, che aprirà alle 10 e si legge tutto...

AREA STAMPA

COMUNICATI PRESS RELEASE

APPROFONDIMENTI

IMMAGINI INFOGRAFICHE

MULTIMEDIA

asimmetrie.it

LHC Italia

INFN Istituto Nazionale di Fisica Nucleare

ScienzaPerTutti

Seguici su Twitter



LE NOSTRE MOSTRE

L'ENERGIA DEL VUOTO

>> 19 gennaio - 10 febbraio 2013, Bologna &

EVENTI

ITALIA DEL FUTURO

Un viaggio alla scoperta delle più significat...



asimmetrie.it

rivista dell'Istituto Nazionale di Fisica Nucleare

home ultimo numero chi siamo archivio in primo piano infografiche abbonamento link

cerca nel sito vai

asimmetrie 14

[massa]

Cari lettori di Asimmetrie, L'argomento trattato in questo numero è difficile, affascinante, con aspetti stupefanti. Al liceo, i concetti di massa e peso procurano certamente qualche difficoltà interpretativa. Che cosa misuri una bilancia non è una domanda a risposta unica. Dipende dal tipo di bilancia. La massa corporea è una sottile angoscia della società moderna ed è un bel modo di definire la massa.

[>] continua a leggere l'editoriale

[scarica pdf] oppure vai alla [versione online]

Richiedi l'abbonamento gratuito alla rivista

[clicca qui]

archivio

[12] [12] [11] [1]

[as] in primo piano

<https://www.infn.it/infn-per-le-scuole/>

<http://www.asimmetrie.it/>

Connection with Research facilities?



Un percorso didattico in “Fisica delle Particelle”



• I prerequisiti

- La tavola degli elementi → SCIENZE
- L’ atomo (la ricerca dei costituenti ultimi ...) → SCIENZE/
FILOSOFIA
- La carica elettrica
- Gli urti e la conservazione della quantità di moto
- La carica elementare → l’ esperienza di Millikan
- La forza di Lorentz
- Il tubo catodico
- Il funzionamento dell’ occhio umano → SCIENZE
- Il CERN → STORIA
- La radioattività’
- Il Laboratorio del Gran Sasso

The screenshot shows the INFN website's 'Offerta per le scuole' page. The header includes the INFN logo and navigation links: home, info, contatti, notizie e stampa, ricerca, servizi di sezione, eventi, attività con l'esterno. The main content area is titled 'Attività con l'esterno' and lists various services: Trasferimento tecnologico, Accordi e protocolli con enti locali e di ricerca, Divulgazione scientifica, and Offerta per le scuole. The 'Offerta per le scuole' section includes a sub-header 'Offerta per le scuole', a 'Seminari' section with a list of topics (e.g., 'La fisica dell'infinitamente piccolo'), a section for 'Visite guidate ai laboratori della Sezione INFN' with a list of topics (e.g., 'presentazione dell'Istituto Nazionale di Fisica Nucleare'), and contact information for requests.

<http://www.ts.infn.it/it/outreach/offerta-per-le-scuole.html>

Connection with Research facilities?



Un percorso didattico in “Fisica delle Particelle”



- La visita ...
 - Un ente di ricerca (inter)nazionale ...
 - Formazione e Ricerca
 - Dalla struttura della materia a livello molecolare a quella atomica e sub-atomica
 - Particelle e interazioni fondamentali
 - Gravità, Elettromagnetismo, Interazione nucleare forte e debole
 - Leptoni e Quarks
 - Vedere le particelle elementari
 - Cosa vuol dire “misurare” una particella elementare?
 - Un po’ di storia della fisica delle particelle elementari
 - Radioattività e Raggi Cosmici
 - Gli ultimi sviluppi ... Il bosone di Higgs?



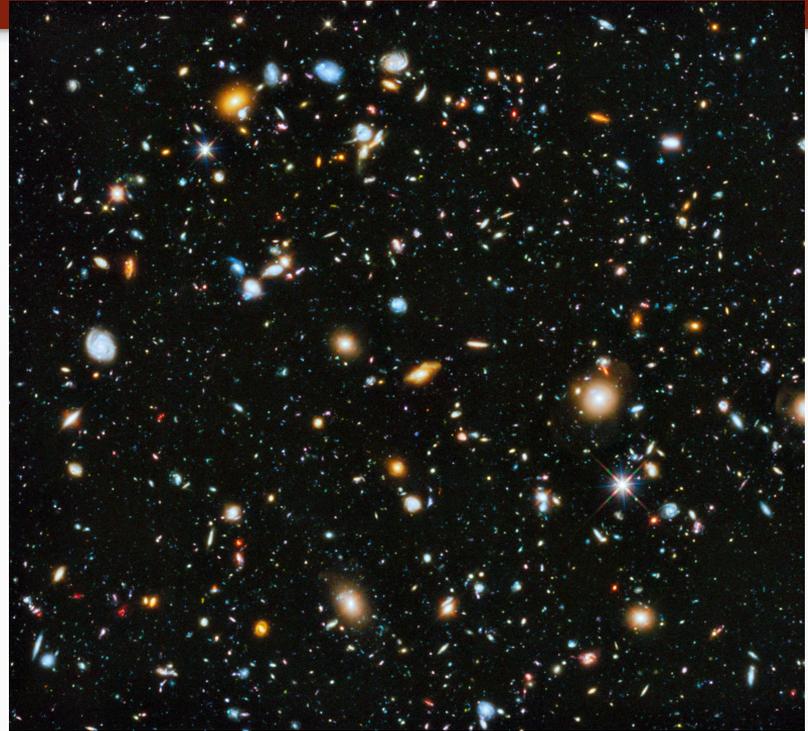
Un percorso didattico in “Fisica delle Particelle”



- Una verifica
 - Le attività’ di ricerca di un fisico delle particelle
 - Acceleratori, Rivelatori, Calcolo
 - $E = mc^2$?
 - Cosa vuol dire rivelare una particella elementare?
 - Tracciatori, Calorimetri, Scintillatori Plastici
 - L’effetto Cerenkov e la rivelazione di particelle
 - Come si costruisce un sistema di acquisizione dati?
 - La radioattività
 - Dove si trova?
 - Il Bosone di Higgs – cosa vuol dire cercare una particella elementare?
 - Particelle elementari dallo spazio?
 - I raggi cosmici
 - Il futuro del calcolo
 - Applicazioni della ricerca in fisica delle particelle elementari.

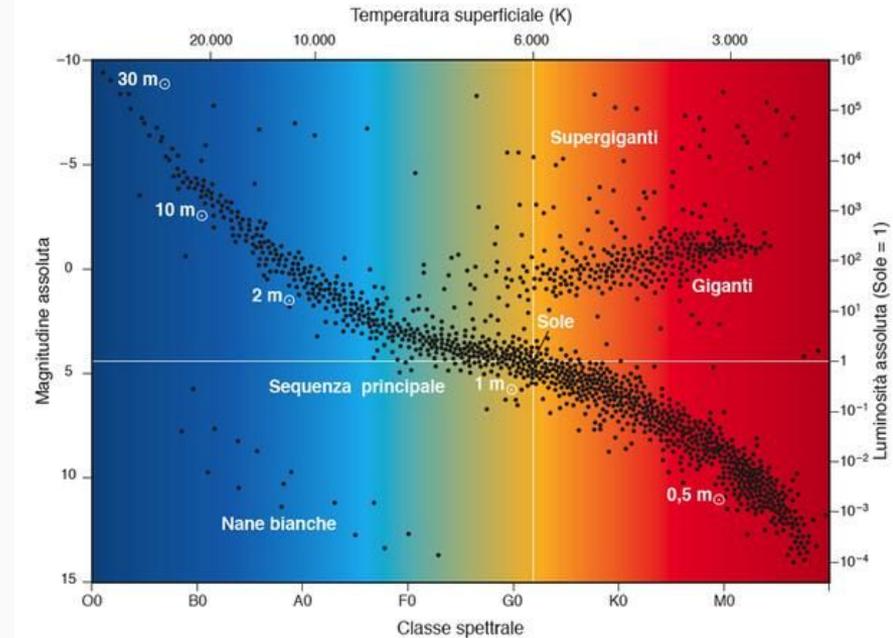
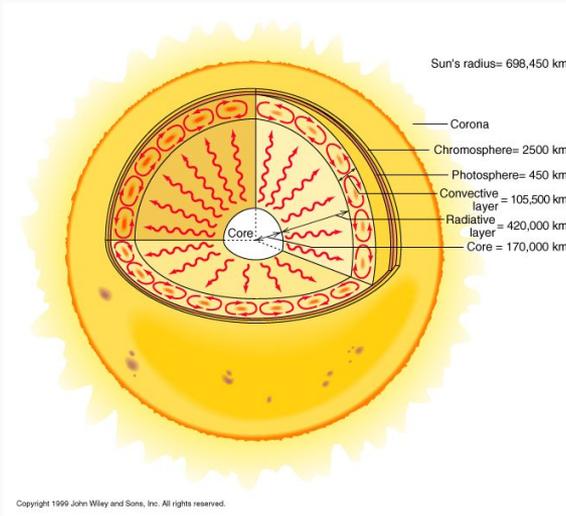
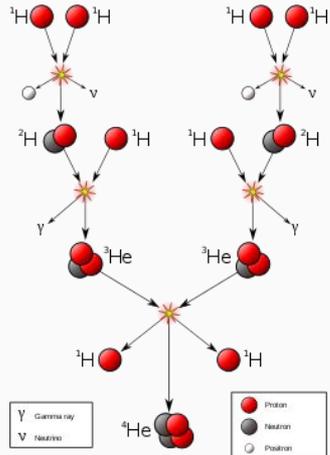
PCK for modern Physics

- To the Universe ...
 - Stars
 - Galaxies and the Universe
 - Cosmology
 - The Big Bang
 - Black Holes & Neutron Stars



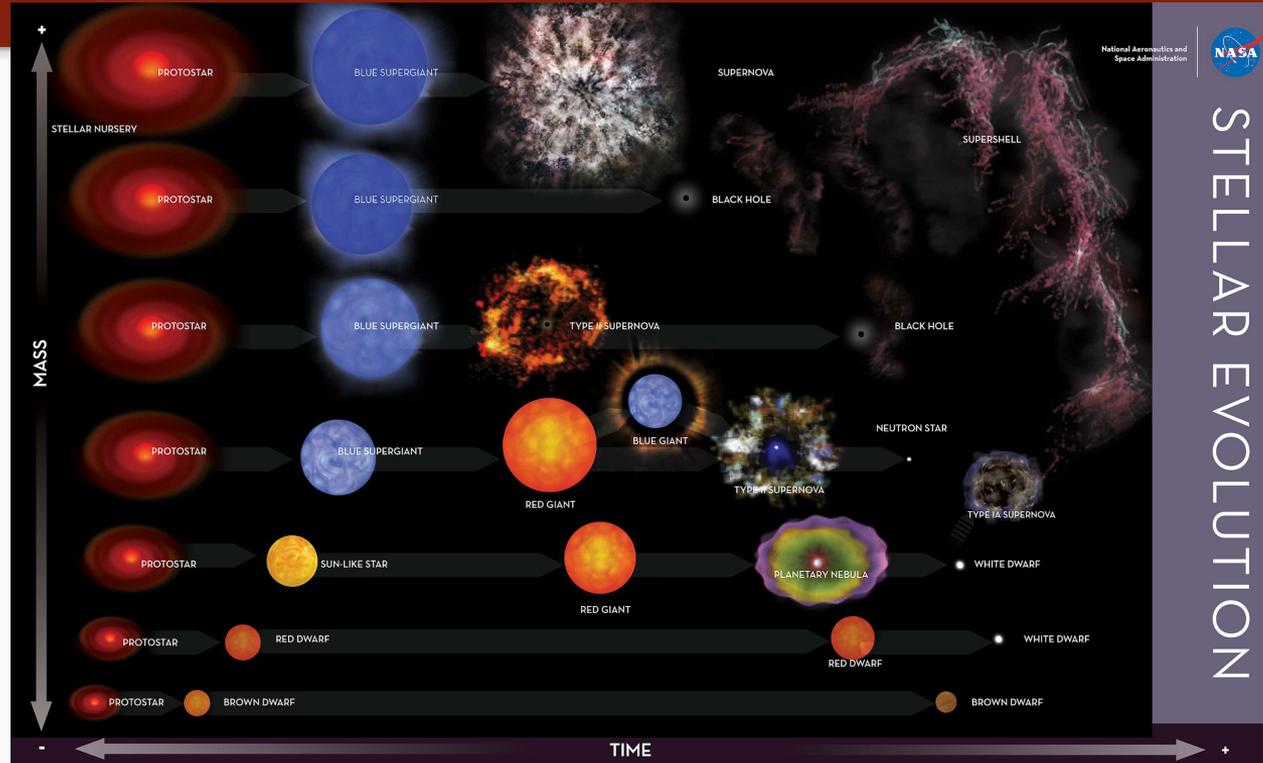
PCK for modern Physics

- Stars
- Stellar evolution



PCK for modern Physics

- Stellar death



PCK for modern Physics

- Galaxies and Cosmology



Our Cosmic Address

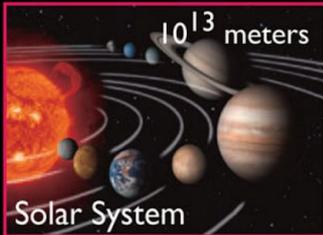
Our sun is one of 400 billion stars in the Milky Way galaxy, which is one of more than 100 billion galaxies in the visible universe.

1.3×10^7 meters



Earth

10^{13} meters



Solar System

10^{21} meters



Milky Way Galaxy

3×10^{22} meters



Local Group

10^{24} meters



Local Supercluster

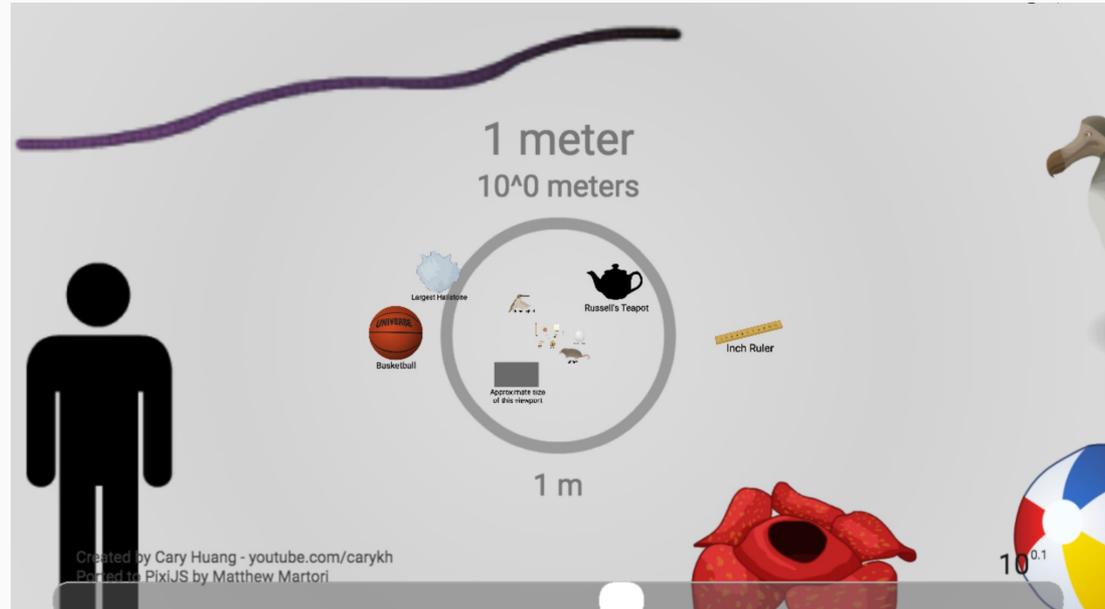
10^{26} meters



The Visible Universe

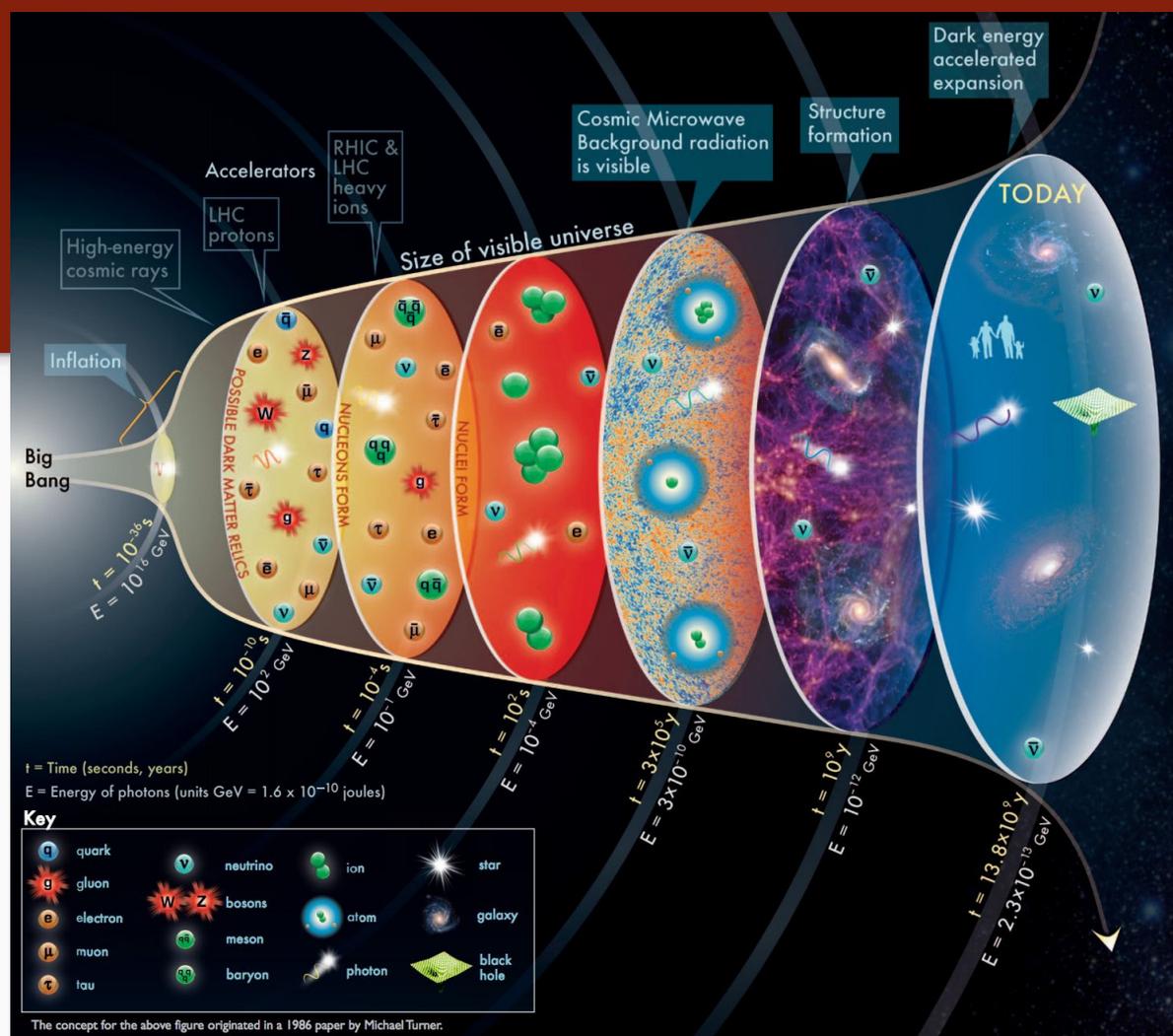
PCK for modern Physics

- Scales of 10



PCK for modern Physics

- The Big Bang model



Materials?

Osservatorio Astronomico di Trieste
Astronomical Observatory of Trieste

INAF

cerca

Tel. +39 040 3199 111
Fax +39 040 309 418
info@oats@inaf.it

Attività INAF-OATs per il pubblico e le scuole

HOME Specola M. Hack SVAS Esploracomo Olimpiadi di Astronomia Il cielo Info e Prenotazioni Contatti

Le attività per pubblico e scuole sono sospese causa Covid-19.

Sospensione attività causa Covid-19

Si informano i visitatori che a causa dell'emergenza sanitaria sono sospese tutte le attività di didattica e divulgazione dell'INAF Osservatorio Astronomico di Trieste.

Risorse Didattiche EDU INAF

Basovizza Ni...

Specola Margherita Hack

La specola Margherita Hack è aperta alle visite del pubblico e delle scuole. Essa dispone di una cupola di nove metri di diametro che ospita un moderno riflettore da 60cm di diametro, accompagnato da due rifrattori per l'osservazione del Sole. Questi telescopi offrono ai visitatori l'emozione dell'osservazione guidata di una grande varietà di corpi e fenomeni celesti, sotto la guida di un astronomo. Al piano terreno è allestita la mostra storica che raccoglie testi, strumenti e notizie sull'attività scientifica degli astronomi triestini e giuliani.

Le Stelle Vanno a Scuola

Attività per studenti delle scuole secondarie di primo e secondo grado, da svolgere dalla propria scuola via internet con i telescopi a controllo remoto della nostra Stazione Osservativa di Basovizza. Le osservazioni sono condotte in aula sotto la supervisione di un insegnante mentre un astronomo, presente in cupola e collegato via audio con la scuola, guida le osservazioni e fornisce supporto scientifico.

Esploracomo

Esploracomo è il laboratorio interattivo della Stazione Osservativa di Basovizza dell'INAF-OATs. Esploracomo è collegato con i telescopi del progetto Le Stelle Vanno a Scuola (SVAS) e permette inoltre di accedere ai dati professionali dell'Osservatorio Virtuale, con software appositamente sviluppato per le scuole nell'ambito del progetto europeo "EuroVO for education". Attività per studenti delle scuole secondarie di primo e secondo grado.

Materials?

EuroVO for education



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[contatti e link](#)

[cambia lingua](#)
[ita](#) / [eng](#) / [ger](#)

Attenzione: il nostro progetto dipende dal vostro gradimento. Se avete trovato utile il materiale che abbiamo sviluppato vi preghiamo di riconoscerlo nei vostri lavori, scriverci una mail o mettere un *mi piace* sulla nostra pagina facebook. [f Like](#)

Scarica i moduli didattici e gli esempi di utilizzo

Gli esempi di utilizzo hanno lo scopo di far familiarizzare gli utenti con Aladin e Stellarium e stimolare ulteriori interesse e attività campo astronomico. Gli esempi di utilizzo sono strutturati come moduli didattici, consistenti in due parti principali. La prima parte presenta un tipico problema astronomico con una breve introduzione e una descrizione della soluzione trovata dagli astronomi o, in alcuni casi, una trattazione più approfondita del problema. La seconda parte è una guida passo passo ai comandi necessari per raggiungere la soluzione con Aladin o Stellarium. Alcuni dei nostri esempi di utilizzo includono esercizi utili per l'attività degli insegnanti in classe. Le soluzioni sono fornite separatamente.

Astronomical Infrastructure for Data Access

[news](#)

[/more news/](#)

Nuovo modulo didattico: ammassi stellari.

[/ 17 dicembre 2017 /](#)

Ammassi aperti e globulari: forma, dimensioni, distanza, distribuzione nello spazio [/... /](#)

Nuovo modulo didattico: il catalogo di Messier.

[/ 17 ottobre 2016 /](#)

Il catalogo di Messier: esplorazione dei principali oggetti del cielo (galassie, nebulose, ammassi, ...) [/... /](#)

Materials?



LE STELLE

G. Iafrate^(a), M. Ramella^(a) e V. Bologna^(b)

^(a) INAF - Osservatorio Astronomico di Trieste

^(b) Istituto Comprensivo S. Giovanni Sc. Sec. di primo grado "M. Codermatz" - Trieste

Questo modulo didattico illustra come costruire il diagramma di Hertzsprung-Russell e quali informazioni sull'evoluzione stellare si possono ricavare dal colore e dalla luminosità delle stelle.

Informazioni e contatti: <http://vo-for-education.oats.inaf.it> - iafrate@oats.inaf.it

Materials?



stellarium
latest version is 0.20.3



Linux
source



Linux
snap



Linux
64 bit;
AppImage



Mac OS X
10.12+; 64
bit



Windows
32 bit



Windows
64 bit



Stellarium
Web



User Guide
0.20.3-1

Stellarium is a free open source planetarium for your computer. It shows a realistic sky in 3D, just like what you see with the naked eye, binoculars or a telescope.



Try the
Web
Version



Full sky view of the constellations, their boundaries, the Milky Way.

[view screenshots »](#)

features

- sky
 - default catalogue of over 600,000 stars
 - extra catalogues with more than 177 million stars
 - default catalogue of over 80,000 deep-sky objects
 - extra catalogue with more than 1 million deep-sky objects
 - asterisms and illustrations of the constellations
 - constellations for 20+ different cultures
 - images of nebulae (full Messier catalogue)
 - realistic Milky Way
 - very realistic atmosphere, sunrise and

news

- Presentation of Stellarium at IAUS367
- Stellarium v0.20.3 has been released!
- Stellarium v0.20.2 has been released!
- Stellarium v0.20.1 has been released!
- Stellarium v0.20.0 has been released!
- Stellarium v0.19.3 has been released!
- Stellarium v0.19.2 has been released!
- Stellarium v0.19.1 has been released!
- Stellarium v0.19.0 has been released!
- Stellarium 0.18.3

system requirements

collaborate

You can learn more about Stellarium, get support and help the project from these links:

- [forum](#)
- [mailing list](#)
- [wiki](#)
- [FAQ](#)
- [scripts](#)
- [landscapes](#)
- [developers documentation](#)

<http://stellarium.org/>

Materials?



  **LIGO** Laser Interferometer Gravitational-Wave Observatory
Supported by the U.S. National Science Foundation
Operated by Caltech and MIT

About Learn More News Gallery **Educational Resources** For Scientists Study & Careers

Teacher Professional Development
Classroom Activities
Field Trips
Bring LIGO To Your Classroom
Ask a LIGO-ite
GW Alerts on your Phone
Recommended Reading, Video
Detection Education Resources
Try This at Home

Educational Resources

Whether you're a K-12 educator, a parent, or an interested student, you should browse our education web pages. There's something fun and educational here for everyone.

- **Classroom Activities** - All sorts of activities you can bring to your classroom that concentrate on LIGO, or concepts related to LIGO (such as, waves).
- **Field Trips** - Want to take a school field trip to LIGO? Click on this link to book a field trip to one of our two observatories.
- **Try This at Home** - Here are some LIGO related activities you can try at home!
- **Ask a LIGO-ite** - Do you have a question that's not answered anywhere else on our site? Click here to ask a question of a real LIGO scientist!
- **Bring LIGO to Your Classroom** - If you can't bring your class to LIGO, then we may be able to bring a LIGO educator to you. Click here to learn more.
- **Teacher Professional Development** - Visit this page to learn about the teacher professional development programs offered through each of our two observatories.
- **Recommended Reading and Video** - Some of our favorite resources related to the science behind LIGO.
- Detection Education Resources - Education materials related to the detection of gravitational waves by LIGO:
 - **Detection science summaries:** Short overviews of LIGO detections tailored to a casual reader
 - **LIGO Educator's Guide** (a 24-page introductory guide to LIGO and gravitational waves, with 2 simple activities suitable for classroom use)

<https://www.ligo.caltech.edu/page/educational-resources>

AI for teaching?

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Digital learning and transformation of education

Artificial Intelligence

Home Ethics of AI AI in Education AI & inclusion Digital Capacity Building Resources

Artificial intelligence in education

<https://www.unesco.org/en/digital-education/artificial-intelligence>

AI for teaching?

OPEN ACCESS

PAPER

Phys. Educ. **58** (2023) 035021 (9pp)

iopscience.org/ped

ChatGPT and the frustrated Socrates

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Abstract

We present a case study of a conversation between ourselves and an artificial intelligence-based chatbot ChatGPT. We asked the chatbot to respond to a basic physics question that will be familiar to most physics teachers: ‘*A teddy bear is thrown into the air. What is its acceleration in the highest point?*’ The chatbot’s responses, while linguistically quite advanced, were unreliable in their correctness and often full of contradictions. We then attempted to engage in Socratic dialogue with the chatbot to resolve the errors and contradictions, but with little success. We found that ChatGPT is not yet good enough to be used as a cheating tool for physics students or as a physics tutor. However, we found it quite reliable in generating incorrect responses on which physics teachers could train assessment of student responses.

AI for teaching?

Performance of ChatGPT on the Test of Understanding Graphs in Kinematics

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Abstract: The well-known artificial intelligence-based chatbot ChatGPT-4 has become able to process image data as input in October 2023. We investigated its performance on the Test of Understanding Graphs in Kinematics to inform the physics education community of the current potential of using ChatGPT in the education process, particularly on tasks that involve graphical interpretation. We found that ChatGPT, on average, performed similarly to students taking a high-school level physics course, but with important differences in the distribution of the correctness of its responses, as well as in terms of the displayed “reasoning” and “visual” abilities. While ChatGPT was very successful at proposing productive strategies for solving the tasks on the test and expressed correct “reasoning” in most of its responses, it had difficulties correctly “seeing” graphs. We suggest that, based on its performance, caution and a critical approach are needed if one intends to use it in the role of a tutor, a model of a student, or a tool for assisting vision-impaired persons in the context of kinematics graphs.

AI for teaching?

ChatGPT as a tool for honing teachers' Socratic dialogue skills

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Abstract

In this proof-of-concept paper, we propose a specific kind of pedagogical use of ChatGPT – to help teachers practice their Socratic dialogue skills. We follow up on the previously published paper “ChatGPT and the frustrated Socrates” by re-examining ChatGPT’s ability to engage in Socratic dialogue in the role of a physics student. While in late 2022 its ability to engage in such dialogue was poor, we see significant advancements in the chatbot’s ability to respond to leading questions asked by a human teacher. We suggest that ChatGPT now has the potential to be used in teacher training to help pre- or in-service physics teachers hone their Socratic dialogue skills. In the paper and its supplemental material, we provide illustrative examples of Socratic dialogues with ChatGPT and present a report on a pilot activity involving pre-service physics and mathematics teachers conversing with it in a Socratic fashion.

Keywords: *chatbots, ChatGPT, GPT-4, GPT-3.5, Socratic dialogue, teacher training, pedagogical skills.*

AI for teaching?

Physics task development of prospective physics teachers using ChatGPT

Stefan Küchemann^{1,*}, Steffen Steinert¹, Natalia Revenga¹, Matthias Schweinberger¹, Yavuz Dinc¹, Karina E. Avila², and Jochen Kuhn¹

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² *Department of Mathematics, RPTU Kaiserslautern-Landau, Paul-Ehrlich-Str. 14, 67663 Kaiserslautern, Germany*

(Dated: April 21, 2023)

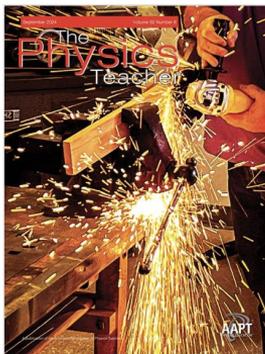
The recent advancement of large language models presents numerous opportunities for teaching and learning. Despite widespread public debate regarding the use of large language models, empirical research on their opportunities and risks in education remains limited. In this work, we demonstrate the qualities and shortcomings of using ChatGPT 3.5 for physics task development by prospective teachers. In a randomized controlled trial, 26 prospective physics teacher students were divided into two groups: the first group used ChatGPT 3.5 to develop text-based physics tasks for four different concepts in the field of kinematics for 10th grade high school students, while the second group used a classical textbook to create tasks for the same concepts and target group. The results indicate no difference in task correctness, but students using the textbook achieved a higher clarity and more frequently embedded their questions in a meaningful context. Both groups adapted the level of task difficulty easily to the target group but struggled strongly with sufficient task specificity, i.e., relevant information to solve the tasks were missing. Students using ChatGPT for problem posing rated high system usability but experienced difficulties with output quality. These results provide insights into the opportunities and pitfalls of using large language models in education.

AI for teaching?



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AI PHYSICS TOOLS (AI@TPT) | SEPTEMBER 01 2024

Using ChatGPT for teaching physics

Karina E. Avila ; Steffen Steinert ; Stefan Ruzika; Jochen Kuhn ; Stefan Küchemann

Check for updates

Phys. Teach. 62, 536–537 (2024)

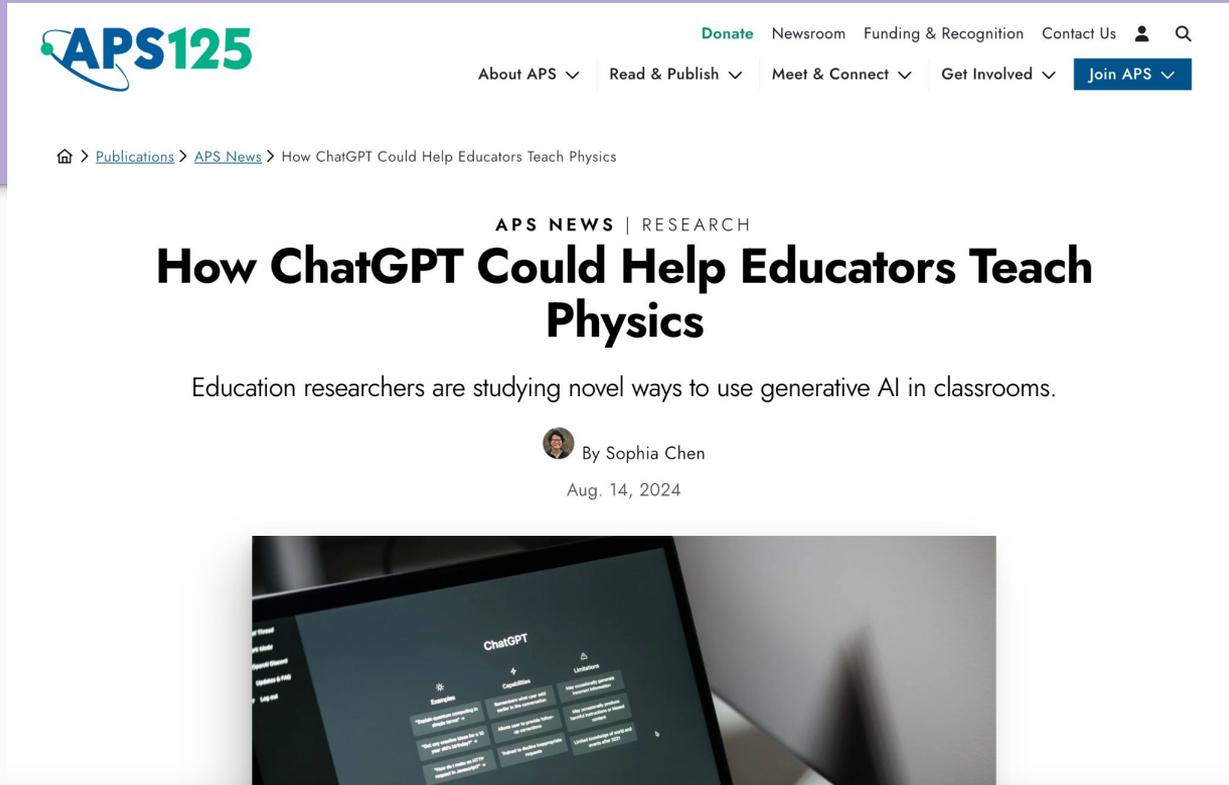
<https://doi.org/10.1119/5.0227132>

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Tools ▾

The emergence of (multimodal) chatbots such as ChatGPT and ChatGPT-4.0-Turbo in education presents a unique opportunity for physics teachers to enhance their instructional methods.¹ These advancements allow teachers to provide more effective and personalized educational experiences to their students. They can be used to generate content and interact with students, providing formative feedback that supports various aspects of self-regulated learning. This capability is particularly beneficial in facilitating personalized learning experiences for students. However, the integration of such large language models (LLMs) into the classroom and regular practices of teachers is not straightforward, as the output is not always reliable¹ and the prompt needs to be well specified.² Additionally, Krupp and colleagues showed that students often copy the task to the chatbot when solving tasks in physics without aiming to solve the tasks themselves.³ Often, the students were not aware that the solution provided by the chatbot...

AI for teaching?



The image shows a screenshot of a news article on the APS125 website. The article is titled "How ChatGPT Could Help Educators Teach Physics" and is categorized under "APS NEWS | RESEARCH". The author is Sophia Chen, and the article was published on August 14, 2024. The article's subtitle is "Education researchers are studying novel ways to use generative AI in classrooms." Below the text is a photograph of a tablet displaying the ChatGPT interface, which includes sections for "Examples", "Capabilities", and "Limitations".

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APS NEWS | RESEARCH

How ChatGPT Could Help Educators Teach Physics

Education researchers are studying novel ways to use generative AI in classrooms.

By  Sophia Chen

Aug. 14, 2024



<https://www.aps.org/apsnews/2024/08/chatgpt-educators-teach-physics>

AI for teaching?

Data Dialogue with ChatGPT: Using Code Interpreter to Simulate and Analyse Experimental Data

Andrew Low¹ and Z. Yasemin Kalender¹

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Artificial Intelligence (AI) has the potential to fundamentally change the educational landscape. Chatbot's such as ChatGPT allow users to engage in conversations that mimic human interactions. So far, much of the physics education research relating to AI has focused on lecture-based assessment and the ability of ChatGPT to answer conceptual surveys and traditional exam-style questions. In this study, we shift the focus by investigating ChatGPT's ability to complete an introductory mechanics laboratory activity by using Code Interpreter, a recent plugin that allows users to generate and analyse data by writing and running Python code 'behind the scenes'. By uploading a common 'spring constant' lab activity using Code Interpreter, we investigate the ability of ChatGPT to interpret the activity, generate realistic model data, produce a line-fit, and calculate the reduced chi square statistic. By analysing our interactions with ChatGPT, along with the Python code generated by Code Interpreter, we assess how the quality and accuracy of ChatGPT's responses depends on different levels of prompt detail. We find that although ChatGPT is capable of completing the lab activity and generating plausible-looking data, the quality of the output is highly dependent on the detail and specificity of the text prompts provided. We find that the data generation process adopted by ChatGPT in this study leads to heteroscedasticity in the simulated data, which may be difficult for novice learners to spot. We also find that when *real* experimental data is uploaded via Code Interpreter, ChatGPT is capable of correctly plotting and fitting the data, calculating the spring constant and associated uncertainty, and calculating the reduced chi square statistic. This work offers new insights into the capabilities of Code Interpreter within a laboratory setting and highlights a variety of text-prompt strategies for the effective use of Code Interpreter in a lab context.

AI for teaching?

Reforming Physics Exams Using Openly Accessible Large Isomorphic Problem Banks created with the assistance of Generative AI: an Explorative Study

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This paper explores using large isomorphic problem banks to overcome many challenges of traditional exams in large STEM classes, especially the threat of content sharing websites and generative AI to the security of exam items. We first introduce an efficient procedure for creating large numbers of isomorphic physics problems, assisted by the large language model GPT-3 and several other open-source tools. We then propose that if exam items are randomly drawn from large enough problem banks, then giving students open access to problem banks prior to the exam will not dramatically impact students' performance on the exam or lead to wide-spread rote-memorization of solutions. We tested this hypothesis on two mid-term physics exams, comparing students' performance on problems drawn from open isomorphic problem banks to similar transfer problems that were not accessible to students prior to the exam. We found that on both exams, both open bank and transfer problems had the highest difficulty. The differences in percent correct were between 5% to 10%, which is comparable to the differences between different isomorphic versions of the same problem type. Item response theory analysis found that both types of problem have high discrimination (>1.5) with no significant differences. Student performance on open-bank and transfer problems are highly correlated with each other, and the correlations are stronger than average correlations between problems on the exam. Exploratory factor analysis also found that open-bank and transfer problems load on the same factor, and even formed their own factor on the second exam. Those observations all suggest that giving students open access to large isomorphic problem banks only had a small impact on students' performance on the exam but could have significant potential in reforming traditional classroom exams.

Teacher's perspectives

- Subject Matter Knowledge (SMK) or Content Knowledge (CK)
- Pedagogical Knowledge (PK)
- Pedagogical Content Knowledge (PCK)
- Content Knowledge for Teaching (CKT)
- Cultural Content Knowledge (CCK)
- Technological Pedagogical Content Knowledge (TPCK)

Course Topics

Student's perspectives

- How students learn
 - Cognitive skills
 - Meta-cognitive skills
 - Assessments
 - Attitude towards physics

Physics perspectives

- Epistemological point of view/development:
 - How Physics works
 - How Physics knowledge is structured
 - How Physicists work
-

Main topics

Useful education tools in PER

Kinematics

Early Physics

Dynamics

Multiple Representations in Physics

Energy

Historical approaches

Fluidodynamics

Problem-solving skills;

Jeopardy problems

Calorimetry/thermodynamics

Physics of everyday Thinking

Optics

Project Based Education

Modelling instruction

Electrostatics

Simulation for Educational Physics

Magnetism

ISLE - Investigative Science Learning Environment

Electromagnetism

IBSE - Inquiry Based Science Education

Quantum Mechanics

Bayesian updating method

On line educational toolkit

Special and general relativity

Specific Learning Disorders

Le Indicazioni Nazionali



Ministero dell'istruzione, dell'università e della ricerca

Schema di regolamento recante "Indicazioni nazionali riguardanti gli obiettivi specifici di apprendimento concernenti le attività e gli insegnamenti compresi nei piani degli studi previsti per i percorsi liceali di cui all'articolo 10, comma 3, del decreto del Presidente della Repubblica 15 marzo 2010, n. 89, in relazione all'articolo 2, commi 1 e 3, del medesimo regolamento."

Le Indicazioni Nazionali

ISTITUTI TECNICI

**LINEE GUIDA PER IL PASSAGGIO AL NUOVO
ORDINAMENTO**

(d.P.R. 15 marzo 2010, articolo 8, comma 3)

ISTITUTI TECNICI

**LINEE GUIDA PER IL PASSAGGIO AL NUOVO
ORDINAMENTO**

Secondo biennio e quinto anno

Le Indicazioni Nazionali

ISTITUTI PROFESSIONALI

LINEE GUIDA PER IL PASSAGGIO AL NUOVO ORDINAMENTO

**(d.P.R. 15 marzo 2010, n. 87, articolo 8,
comma 6)**

ISTITUTI PROFESSIONALI

LINEE GUIDA PER IL PASSAGGIO AL NUOVO ORDINAMENTO

Secondo biennio e quinto anno

Course Final Exam

1. Choose a subject
 2. Choose a teaching approach
 3. Discuss the adopted teaching approach based on PER literature search
 4. Create your own educational case
 5. Elaborate a report
 6. Prepare a laboratory to test it
-

Evaluation CKT - based

1. Coherence
 - Activities - Age
 - Educational Strategies
 2. Completeness
 - Pre - During - Post
 - Attention to DSA
 3. Clarity of presentation
 - Availability of material
 - Presentation
 - Description of activities
 - Discussion
-

How to?

1. Define a classroom
 - Age, Number, Learning Disorders
2. Choose a topic
 - Look at “Indicazioni Nazionali”
 - Prerequisites, Possible “pre”-instruction ideas
3. Prepare the lectures
 - Coherent pedagogical approach
 - Number of hours - Activities
 - Homework
 - Assessment (which?)
4. Prepare a laboratory to test
 - Prepare the material to guide the lectures (tables, videos, laboratory, graphs, exercises, etc)