

28th IPPOG meeting 25.–27. Nov. 2024

Inspirational Success Stories

Tactile Quark-Puzzle

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27th of November

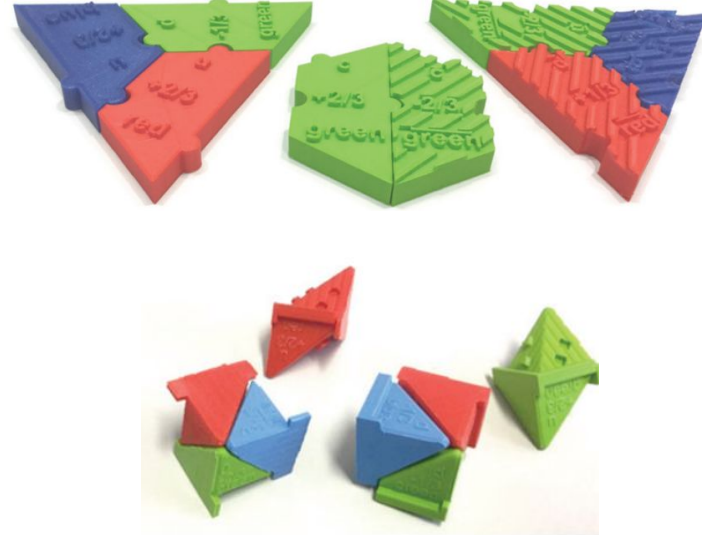
Existing Quark-Puzzle

Currently available
at CERN Science
Gateway and
IPPOG/Games



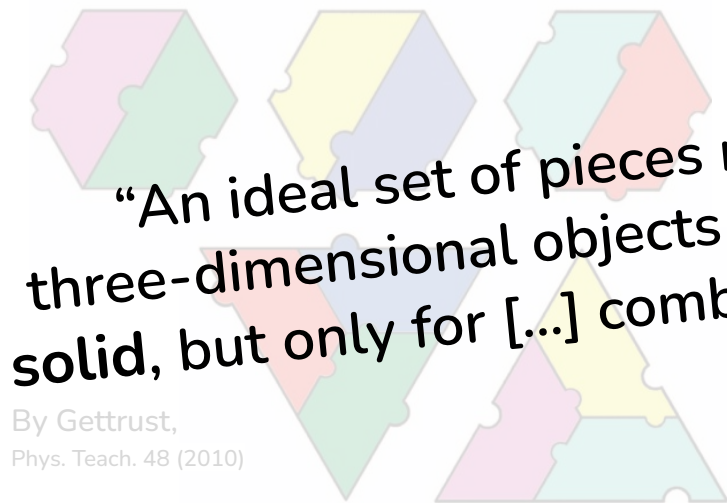
By Gettrust,
Phys. Teach. 48 (2010)

By McGinness et al.
Phys. Teach. 57 (2019)



Existing Quark-Puzzle

Currently available
at CERN Science
Gateway and
IPPOG/Games



“An ideal set of pieces representing quarks would consist of three-dimensional objects [...], such as a sphere or some platonic solid, but only for [...] combinations allowed by Standard Model [...].”

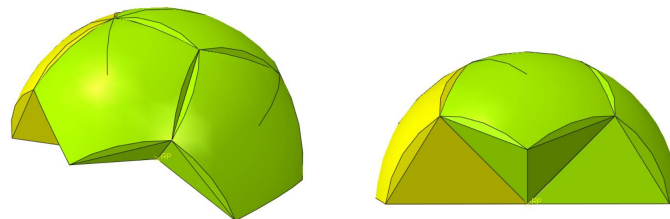
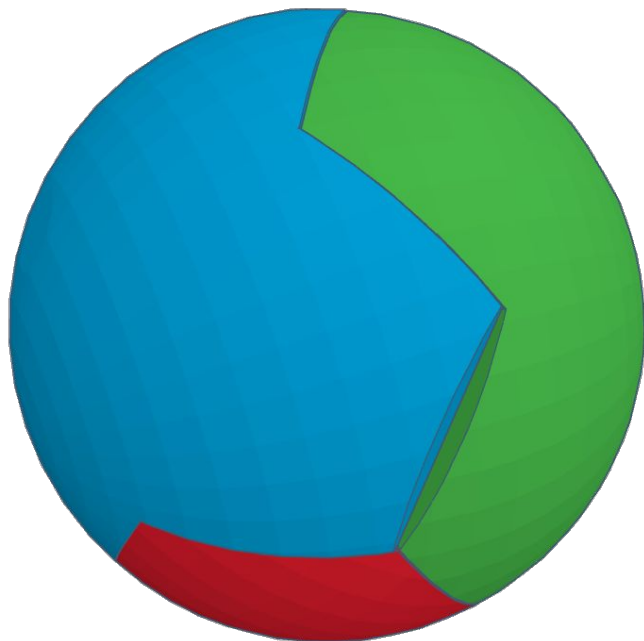
By Gettrust,
Phys. Teach. 48 (2010)

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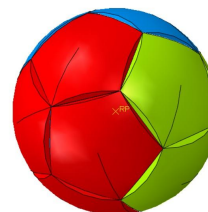
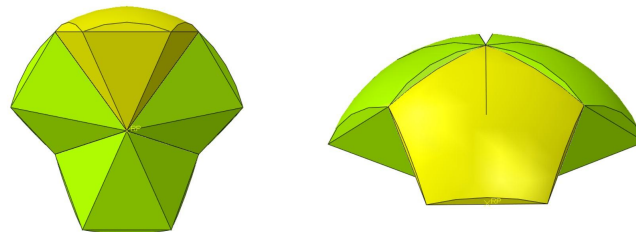


(Gettrust, p. 312)

Solution: (Spherical) Dodecahedron

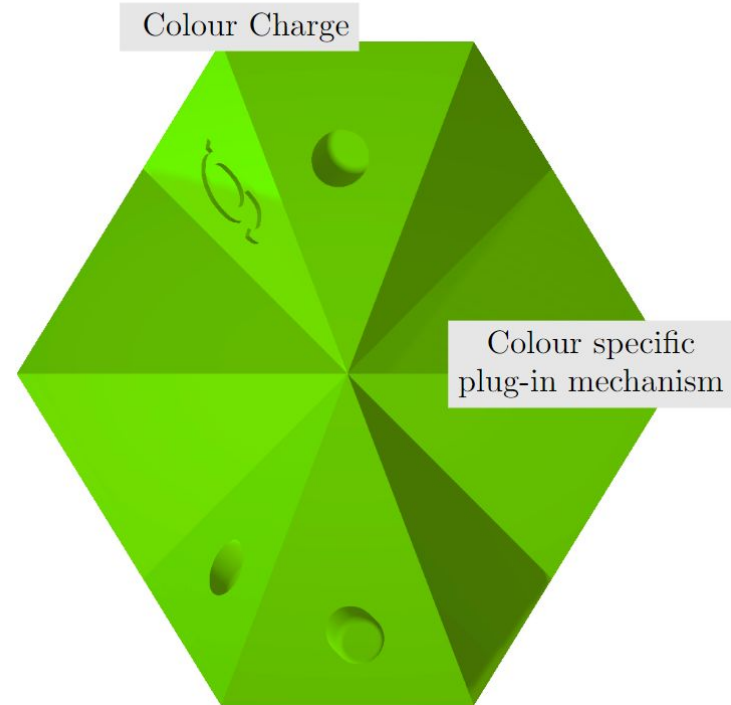
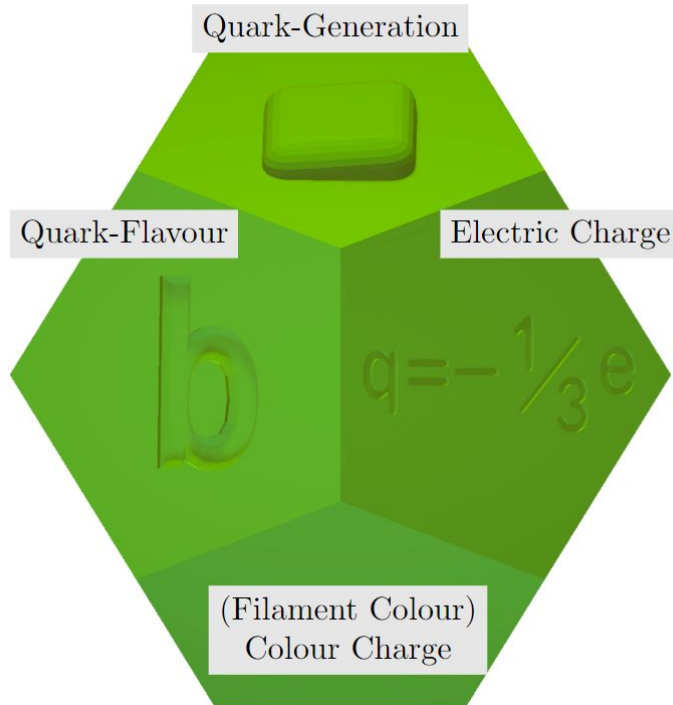


Model of a quark

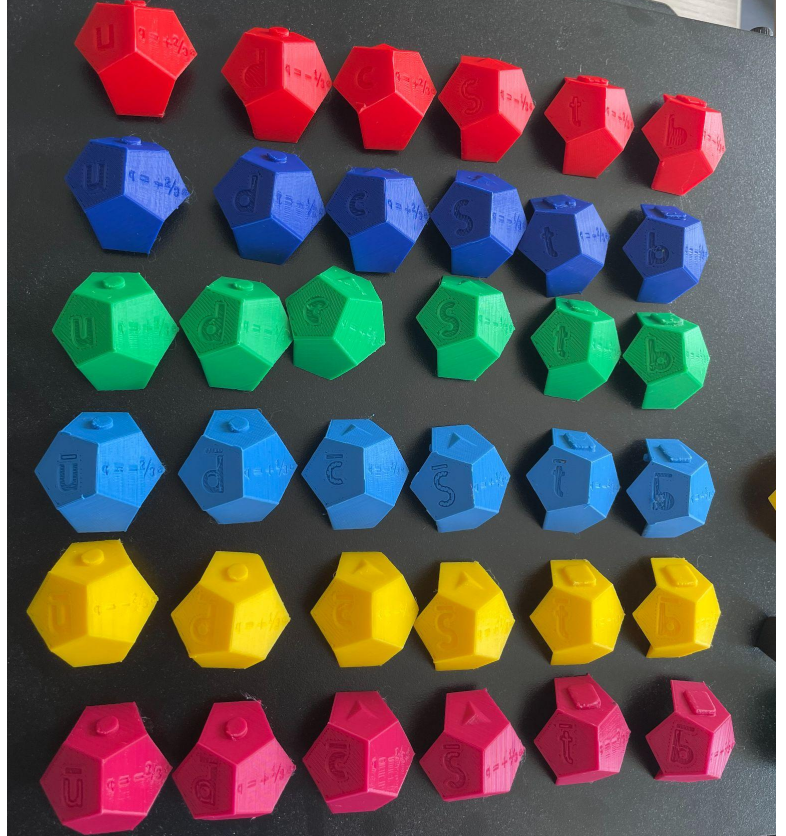
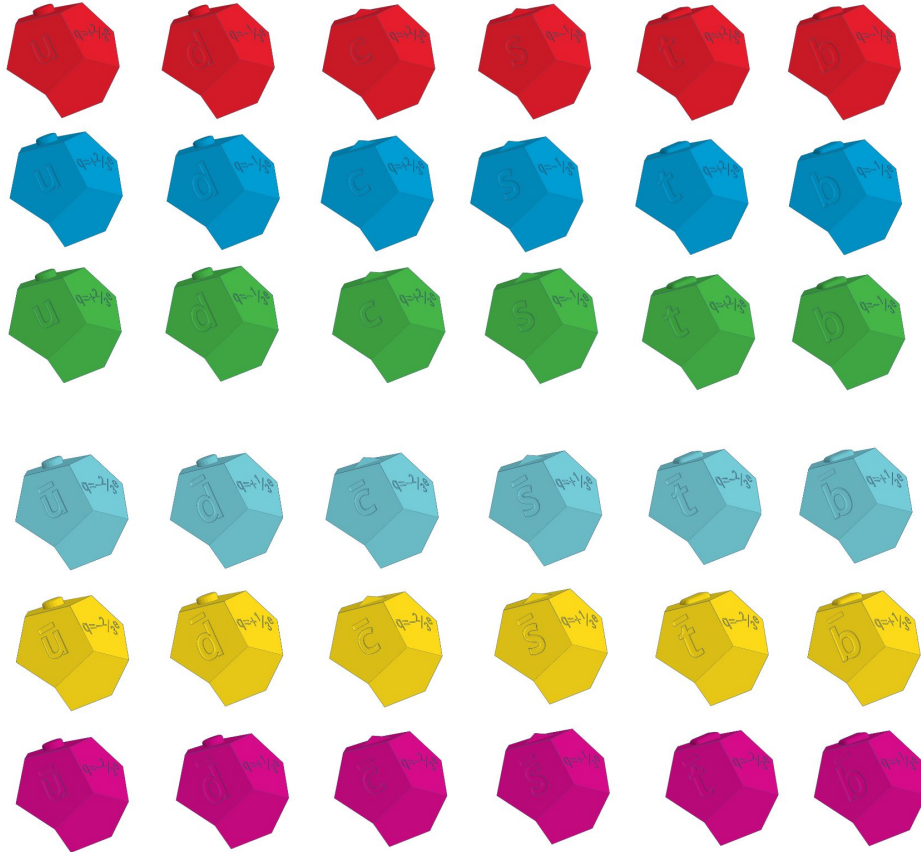


Target Body
(Baryon)

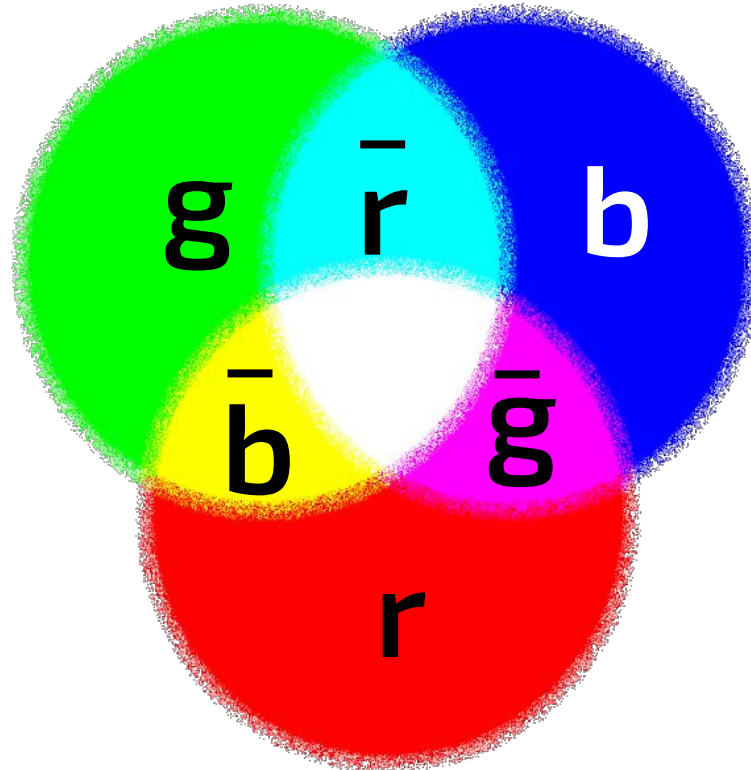
Solution: Dodecahedron



The Standard Model of Particle Physics



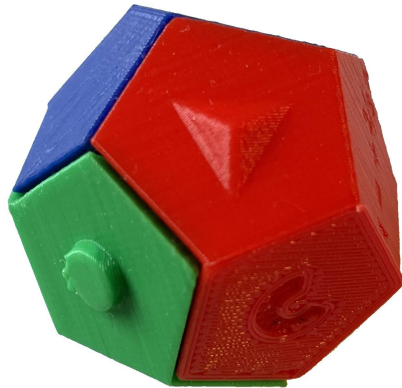
Solution: Additive Color Mixing



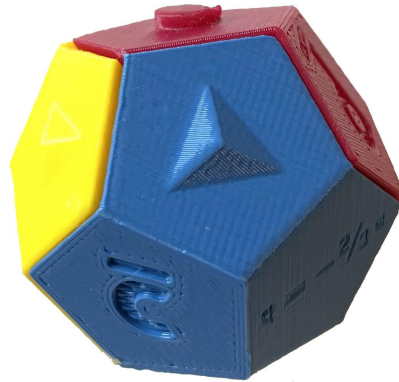
Hadrons



Baryons

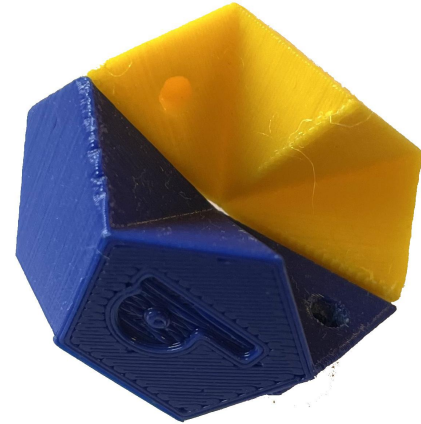


Anti-Baryons



Mesons

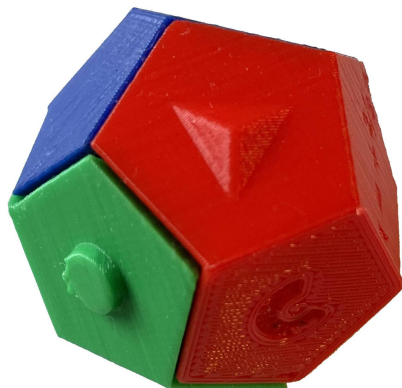
(3 in total)



Only colour-neutral hadrons can be built!

Hadrons

Baryons

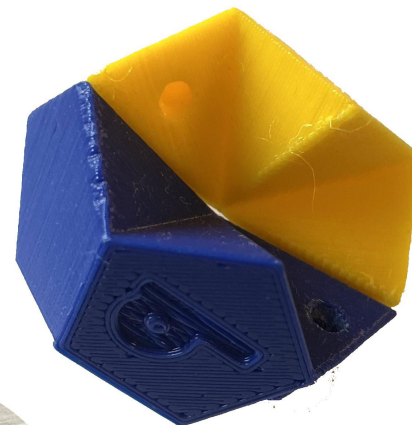


Anti-Baryons

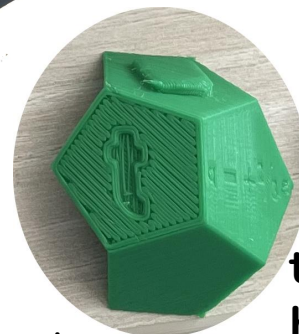


Mesons

(3 in total)

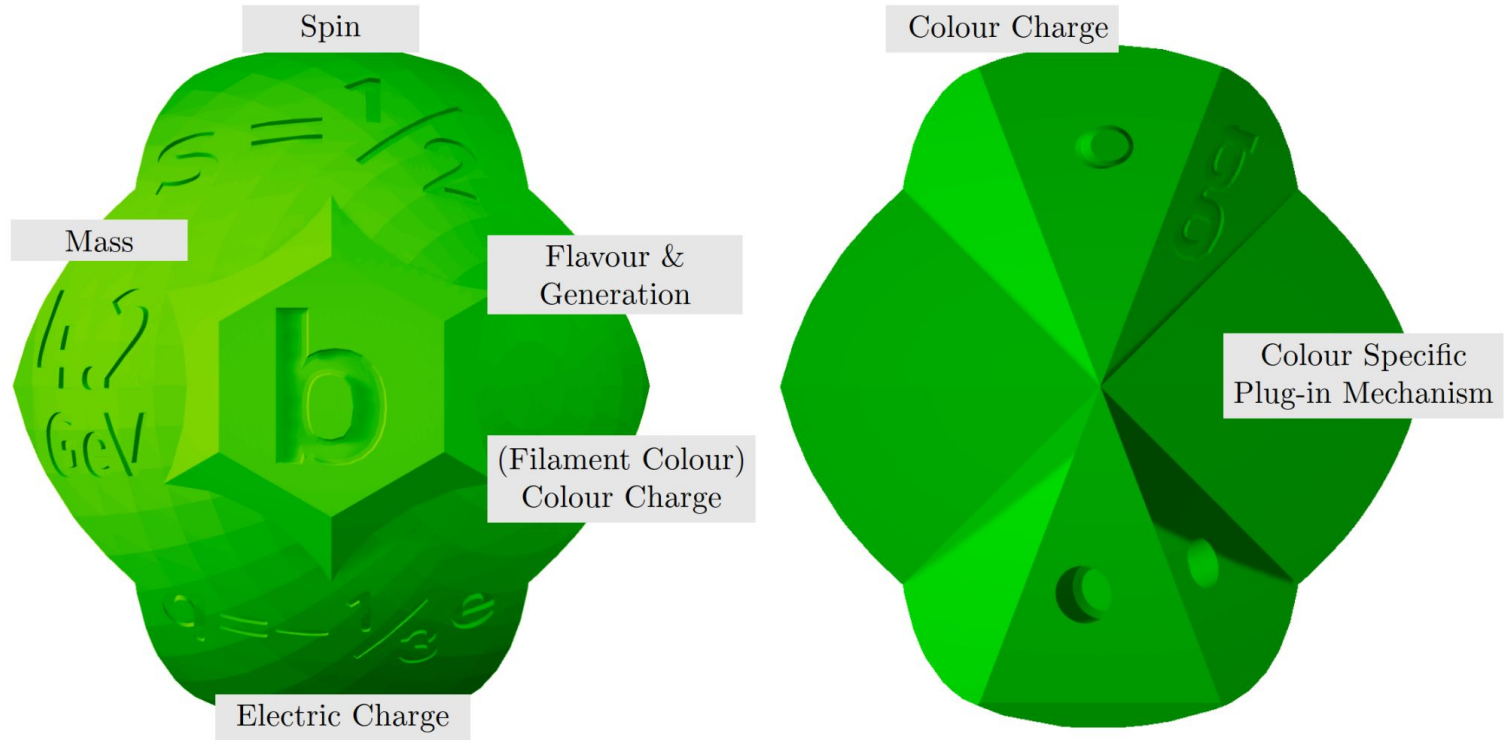


Only colour-neutral hadrons can be built!



top-Quarks
have no plugs!

Solution: Spherical Dodecahedron



Hadrons



Baryons



Anti-Baryons



Mesons

(3 in total)



Only colour-neutral hadrons can be built!

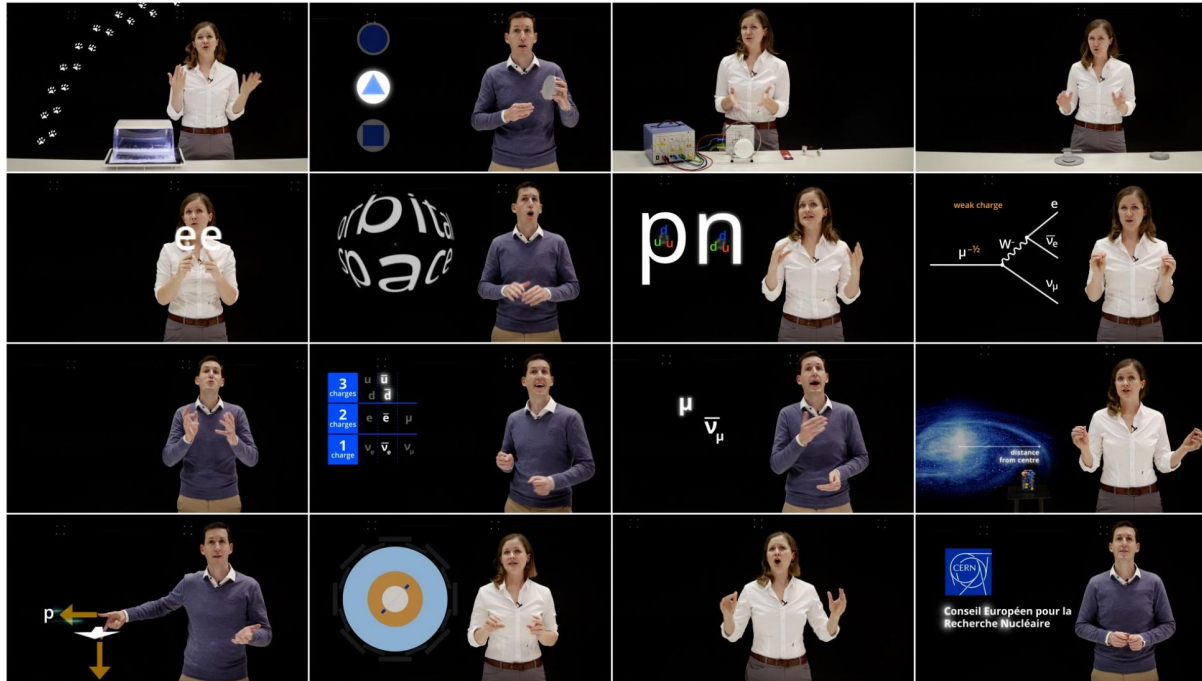


Usage of Quark-Puzzle

Inquiry Learning vs. Teacher-Centered-Instruction



Traditional Approach of Explaining Particle Physics:



From
ppc.web.cern.ch

cf. Talk from
[Jeff Wiener](#) &
[Julia Woithe](#)

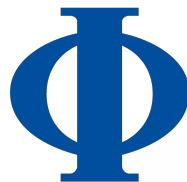
Our Approach: Inquiry Learning

(cf. Mastropieri et al. 1997)

- Gamification
- Playful discovery of the Quark Model of hadrons
- Activating, challenging, inductive thinking → interest-building
(Ryan & Deci 2000)
- Creation of a mental representation independent of specialised vocabulary and mathematics
(cf. T. de Jong et al. 2023)
- Creating a basis for talking about particle physics

Usage: Current Utilisation

+ LHCb
Masterclass



UNIVERSITÄT
HEIDELBERG
ZUKUNFT
SEIT 1386



SPIEL
Essen



3. – 6. OKT 2024 →

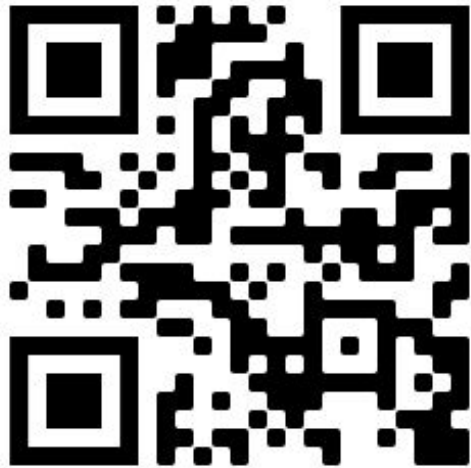


Do you want to try it out too?



Print for FREE (under CC BY-ND)

exner@hiskp.uni-bonn.de



github



printables



Thank you!



github

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exner@hiskp.uni-bonn.de



printables

References

T. de Jong et al., Let's talk evidence – the case for combining inquiry-based and direct instruction, *Educational research review* 39 (2023).

E. Gettrust, The quark puzzle: A novel approach to visualizing the color symmetries of quarks, *Phys. Teach* 48 (2010) 312.

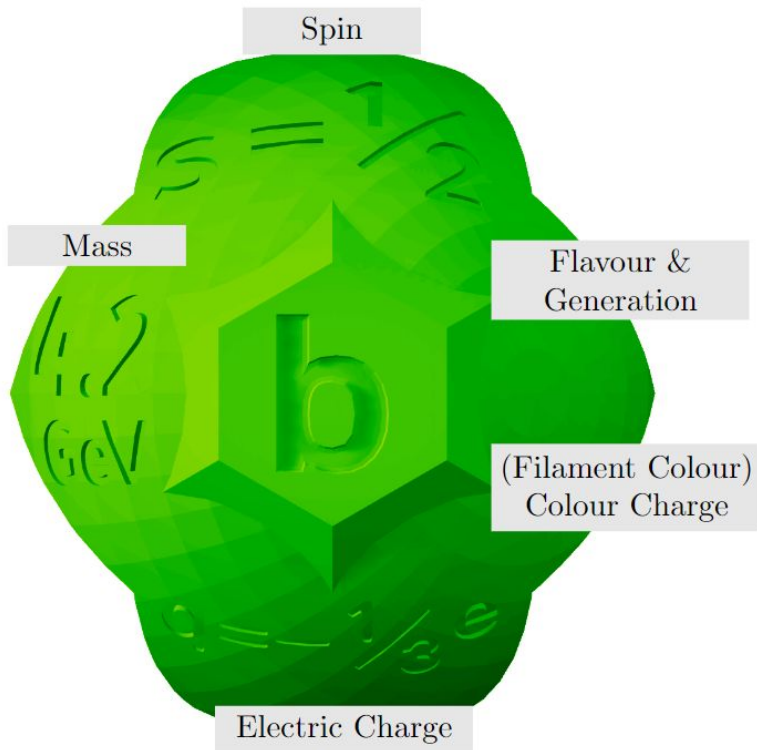
Mastropieri, M. A., Scruggs, T. E., & Butcher, K. (1997). How effective is inquiry learning for students with mild disabilities? *The Journal of Special Education*, 31, 199-211.

L. McGinness, S. Dührkoop, J. Woithe, and A. Jansky, 3D Printable Quark Puzzle: A Model to Build Your Own Particle Systems, *The Physics Teacher* 57 (2019) 526.

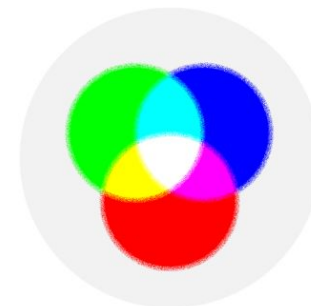
R. Ryan and E. Deci, Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being, *The American Psychologist* 55 (2000) 68.

Additional Slides

Concepts to be taught



- Colour neutral baryons, mesons and anti-baryons
- only stable hadrons
 - i.e. top-quarks do not form a hadron
- Electrical charge of quarks and of hadrons
- Colour charge of quarks and hadrons
- Flavour
- Generation
- (Mass)
- (Spin)



Mathematical description

