

# Adversarial Questions

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## 1 The Questions

### 1.1 Fine Structure Constant

The answer to both the pyramidal and multiple choice question below is the fine structure constant,  $\alpha \approx \frac{1}{137}$ .

#### 1.1.1 Pyramidal

Measurements of this were conducted in 1916 by a Brandenburg-based researcher who hosted Ho Zah-wei ( 何澤慧 ), who would later go on to lead the neutron flux team of the Chinese nuclear program. Those experiments estimated that the reciprocal of this quantity was .9 higher than the three-digit integer value popularly associated with it. For 10 points, name this constant symbolized by  $\alpha$  that controls strength of the electromagnetic interaction between elementary charged particles, approximated as  $\frac{1}{137}$ .

#### 1.1.2 Multiple Choice

The researcher who lead the neutron flux team of the Chinese nuclear program helped a Brandenburg-based researcher estimate the reciprocal of what quantity to be .9 higher than the three-digit integer value popularly associated with it in 1916 experiments?

### 1.2 Explaining the Answer

He Zehui was one of the leading minds of the Chinese nuclear program, but she was educated in Germany; while there, she stayed at the home of Friedrich Paschen [European Organization for Nuclear Research, 2011]. Paschen was notably one of the foremost investigators of spectral lines, which led to his estimation of the reciprocal of the fine structure constant as 137.9, confirming the theory of Sommerfeld.

However, the fine structure constant is typically thought of as  $\frac{1}{137}$ , whose integer value was described as Feynman as being “written by the hand of God” [Feynman, 1998].

### 1.2.1 Distractors

The multiple choice distractors are other well known physical constants, including another one (Proton to Electron Mass Ratio) that is almost an integer. They are not confusable with the correct answer because the mass ratio was discovered much earlier, Planck's constant was investigated about the same time but does not have an almost integer reciprocal, and the Rydberg constant was measured in Sweden. None are associated with He Zehui.

## 1.3 Why it's Interesting

**Why ask about this topic?** The fine structure constant is worthy to ask about because it is one of the few constants in physics that doesn't need to be described in terms of units, in contrast to constants like the speed of light which require things like meters and seconds to be defined. In other words, you could communicate the fine structure constant more easily to an alien than other fundamental physics constants. (One could argue that  $\pi$  our prime numbers would also fit the bill.)

**Why are these facts interesting?** The question asks about the specific value of the constant, which is still being measured recently [Kleppner, 2006]. It also connects Friedrich Paschen who made the *first* measurement of this constant to He Zehui, who was critical to the Chinese nuclear program [Lewis and Xue, 1991].

**Why is this gettable for a knowledgeable human?** The hint about the constant being nearly an integer is often asked about in trivia questions:

- This constant, used to measure some electromagnetic interactions, equals Coulomb's constant times elementary charge squared divided by the quantity h-bar times c. It is approximately 1 over 137.
- The fine structure constant is dimensionless, and has the same value in any unit system. Its value is usually approximated as 1 over this integer.
- For 10 points, name this coupling constant of electromagnetic interactions, which is equal to approximately one over 137 and is symbolized alpha.

And some questions even ask for the integer value. So this is difficult for a good trivia player, but not impossible.

## 1.4 Why it's hard

A simpler version of this question would be: Friedrich Paschen estimated that the reciprocal of what constant proposed by Sommerfeld was 137.9 (not an integer!) in a 1916 experiment?

This question is substantially easier to answer because the fine-structure constant is popularly associated with the integer 137 (one of the few constants not to be a long decimal).

Moreover, it mentions Sommerfeld, a relatively well-known German physicist, who proposed the fine-structure constant [Sommerfeld, 1916].

We make it harder by adding a multi-hop step [Yang et al., 2018] to connect to Paschen and then forcing the system to do numerical reasoning to get the clue that this value is nearly an integer [Dua et al., 2019].

We also make it harder by giving a toponym of Potsdam (Brandenburg) and giving an alternate transliteration of 何泽慧 rather than the more common pinyin.

The additional clue about He Zehui can help point a human in the right direction but might distract the computer.

## 1.5 What do QA systems answer?

- **ChatGPT:** Unfortunately, the given information is not sufficient to determine the answer to this question.
- **You.com:** The quantity being referred to in the question is the proton-electron mass ratio. In 1916, a researcher named Theodore Lyman conducted experiments to estimate the value of this ratio, and he found that the reciprocal of the ratio was about 0.9 higher than the three-digit integer value that was popularly associated with it at the time. The researcher who hosted Ho Zah-wei in his home was James Franck, who was a friend and colleague of Lyman's.

## References

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