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ANIMATION SCRIPT

CAN WE UNLOCK THE SECRETS HIDDEN DEEP WITHIN THE NUCLEUS OF AN ATOM? DR DANIEL PITONYAK

TO MAKE THE MOST OUT OF THIS SCRIPT, YOU COULD:

- Stick it in your book as a record of watching Daniel's animation
- Pause the animation and make notes as you go
- Add your own illustrations to the sheet
- Create your own animation to accompany it
- Add notes from classroom discussions
- Make notes of areas you will investigate further
- Make notes of key words and definitions
- Add questions you would like answered – you can message Daniel through the comments box at the bottom of his article: **www.futurumcareers.com/can-we-unlock-the-secrets-hidden-deep-within-the-nucleus-of-an-atom**

SCRIPT:

Until the end of the 19th century, everything was thought to be made of atoms, and that these atoms were the fundamental units of matter. Indeed, the word atom comes from the ancient Greek word 'atomos', meaning 'indivisible'.

However, we now know that atoms are composed of even smaller particles. Each atom comprises electrons orbiting a very small, dense nucleus made up of protons and neutrons. These protons and neutrons can be split into smaller components still, called quarks, held together by gluons. Quarks and gluons are types of 'elementary particles' that cannot be further subdivided. Collectively, quarks and gluons are known as partons. The larger particles composed of quarks and gluons, such as protons and neutrons, are known as hadrons.

Dr Daniel Pitonyak, a nuclear physicist at Lebanon Valley College, is investigating the internal structure of hadrons.

Spin is a fundamental property of a particle, and can be thought of as similar to the angular momentum of a sphere rotating on its axis, although the particle is not literally spinning. This has the effect of essentially creating a bar magnet within the particle. Spin can be measured by observing the direction that a particle is deflected when passing through a magnetic field.

Protons, neutrons, electrons and quarks all have a spin of $\hbar/2$, while gluons have a spin of $\hbar$. Since a proton is composed of quarks and gluons, its spin of $\hbar/2$ must arise from the sum of its partons' spins and orbital angular momenta.

However, exactly how much of a proton's spin comes from each component remains a mystery, and this is something Daniel continues to work on. What makes this difficult is the proton actually contains a complicated 'sea' of quarks and gluons, each with their own spin and moving around inside the proton.

As partons are billions of times smaller than the width of a human hair, to study them, experimental physicists must smash protons together at incredibly high speeds. When the protons collide, their partons are ejected, allowing physicists to detect the hadrons they form.

Daniel numerically models the results of these experiments, based on equations of how quarks and gluons interact when protons collide, and compares his models with the experimental data. From this, he can discover how the partons move within the protons and create images of their 3-dimensional structure.

Daniel's research will help physicists understand what we are all made of, at a fundamental level.

What could you achieve as a nuclear physicist?