

### **Balliol College Physics: Dr Raghavendra Srinivas – video transcript**

The tutor, Dr Raghavendra Srinivas, is seated, facing the camera. The tutor's name and course subject are shown the first time they appear. The tutor answers the questions that are displayed on screen.

>> DR RAGHAVENDRA SRINIVAS (EARLY CAREER FELLOW IN PHYSICS): Hi, my name is Ragu. I'm an Early Career Fellow here at Balliol College, and at the Physics Department. I grew up in Singapore, before I did my PHD in the US, and then I came here to Oxford in 2020. I've been part of the College since '22, where I teach the undergraduate quantum mechanics class. My research has focused on experimental quantum physics, where manipulating single charge atoms or ions. So, for example, one of our applications is in quantum computing where we're trying to develop new techniques to manipulate these atoms, and the information stored in these atoms more precisely. So, you can think of them as storing zeros and ones within the atom. But what makes it different to a classical computer is that they're not just zero and one, but they can be both zero and one simultaneously in what we call a superposition state. We've also developed new techniques to entangle these ions without lasers, which is my focus during my PhD. Since my research has spread a little bit more to outside quantum computing, to quantum sensing where we can use these ions as clocks to measure really small differences in frequency and time, and also just more fundamental quantum optics. So, the thing to bear in mind is that I'm an experimentalist. So, 90% to 99% of the time something's broken, and you just have to fix it. But the one percent of the time it's all working, and you're taking data, it's just like magic.

[Question displayed on screen:]

#### **What qualities do you look for in students?**

>> DR RAGHAVENDRA SRINIVAS: I think the most important quality I'm looking for in the student is curiosity. I think it's always nice when you can approach this subject with humility. You're there to learn, and what I try to encourage my students to do is to always ask questions. I think there's no such thing as a dumb or stupid question. The only stupid question, I feel, is the one that's not asked. So, I think here, questions are always an opportunity for us to learn, and not so much an opportunity to be embarrassed, and that's something I try to encourage them to do more.

#### **What type of work do students have to do, outside of tutorials, to help them prepare?**

>> DR RAGHAVENDRA SRINIVAS: The students are first exposed to the material at the lectures (which usually happen in the mornings), and then we have the tutorial scheduled in the afternoons. This is where we go through problem sheets set by the main lecturer. It's down to the students to complete the problem sheet ahead of the tutorial. I usually ask them to hand them in a couple of days before the tutorials, I get to look at them ahead of the class. And then, when we're at the tutorial itself, I first give them a brief overview of the material that we're going through – you know, just at a high level – and I try to ask them if they had any questions on the lecture. Then, we dive into the details of the tutorial, and we're going into the details of the problems that they've been set. I try to focus more on the problems that they've had issues with, and concepts that they have issues with in general. A lot of the learning needs to be self-driven, and it happens outside of the lecture. I think if you just go for the lectures, it's not enough exposure to the material to actually learn it.

[Question displayed on screen:]

**How are tutorials structured?**

>> DR RAGHAVENDRA SRINIVAS: In our tutorials, we go through the problem sets that are set by the main lecturer. So, we have a list of questions for every problem set. Then, we go through them in the class. So, one thing to bear in mind is, at Oxford, the tutorial sizes are really small. So, it's about two to three students typically, and we're going through the problems in a lot of detail. So, in my tutorials, I feel the students get enough of someone else just giving them materials, so I try to get the students themselves to present the problems that they solved, and we really just try to focus on the problems that they've had trouble with. As an experimentalist, I do try to give them more of an experimental flavour to the course, and I try to point out where, for example, specific experiments have been done that demonstrate the particular bit of quantum theory that we're looking at. I think what I want to get across is that quantum mechanics doesn't just live on a piece of paper or on the whiteboard, but it's very much, we're able to create all of these states in the lab with actual matter.

[Question displayed on screen:]

**What topics do you explore in your tutorials?**

>> DR RAGHAVENDRA SRINIVAS: It's a quantum mechanics course, it's more focused on the theory. But, being an experimentalist, what I try to do is to point out various aspects of the theory that has been demonstrated experimentally, and to give the flavour that the quantum mechanics that we're doing doesn't just live on a piece of paper, on the whiteboard. It's something that we're actively exploring, and we can create all of these states – for example, entangled states in atoms or photons or any other physical platform.

[Question displayed on screen:]

**What do you enjoy about the conversations you have in your tutorials?**

>> DR RAGHAVENDRA SRINIVAS: What I really enjoy about my interactions with the students is the curiosity and enthusiasm they bring to the subject. I do notice, through my interactions with them, how much I take for granted. I think it's really nice to be able to approach the subject again through their eyes, and to see it afresh. Quantum mechanics is complicated, and there are many different ways of understanding. I have a particular understanding that I've developed throughout my time in the field, and I think what's really nice is that, working with the students, they look at it in a slightly different way. They ask me questions about aspects of quantum theory that I just haven't thought about before, or from a different perspective. So, I think in many ways it also deepens my understanding of the subject.

**What is the best thing about teaching at Balliol?**

>> DR RAGHAVENDRA SRINIVAS: There's a great group of tutors and lecturers here at the College, specialising in different aspects of physics. So, not just quantum physics, but also particle physics, string theory, atomic physics. It's nice to be a part of that community, and to interact with them, and to learn from them. I think, for the students, it's also nice to interact with physicists who have slightly different takes on the various subjects that they're teaching. I should also mention the fantastic library that we have. When I first joined the College, I was asked by the head librarian 'Are there any books that you want to add?', and I just felt like a kid on Christmas. I just gave him a list of some of

my favourite books that weren't there at the library already. They were ordered, and I've even encouraged my students to take a look at some of these texts outside of class.

[Question displayed on screen:]

### **What other opportunities do the students have to explore Physics?**

>> DR RAGHAVENDRA SRINIVAS: Beyond the formal curriculum that the students have – so, lessons, tutorials, lab practicals – there are also a lot of opportunities to engage with the vibrant research community here at Oxford. So, specifically in our group, it's quite common that we take summer interns - either after the second or third year – and they're able to do research in our lab. So, this is for a period of about eight to twelve weeks. Then, we get them in our lab, we get them to work with lasers, microwaves, optics, and they end up doing quite substantial projects with us. More often than not, these summer internships can also extend to the masters project that a lot of students do in their fourth year. That's a little bit more involved, and that's also done during the term time – not just during the summer. Beyond that, a lot of the master students that we've had - we've been really lucky with the students that we've gotten – they've also stayed to do a DPhil with us.

[Question displayed on screen:]

### **What outreach activities can prospective applicants get involved in within the Physics Department?**

>> DR RAGHAVENDRA SRINIVAS: There's a wide variety of programmes available to students in Year 12 and younger to engage with not only the College, but the Physics department. One of the more recent ones was a quantum impact day, where we had Year 10 students visit labs at the department, and they were able to get a flavour of the type of research that we do. But also, a bit of an introduction to quantum physics. The other programme that I've helped set up here at the university is a quantum focused summer experience for Year 12 students – specifically from disadvantaged backgrounds – where they come to us for a week. They have lab placements where they're able to interact closely with researchers at the department. Then, we also arrange for them to have quantum physics courses where they learn, for example, how to code quantum circuits, and even run them on actual quantum computers. We also gave them tours of the local quantum computing companies, as well as the national quantum computing centre that helped fund this programme to begin with. In many ways, I think these outreach programmes are one of the most important things that I do, because I think it's important for me that quantum physics, our people, our students believe that quantum physics isn't just for students who are children of professors or engineers or scientists. It's accessible to anyone who's willing to work hard and is enthusiastic about the subject.

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