Key words: Black Hole, Rebuttal, Stripped Star, HR 6819

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<tr><td>ESOcast Episode 252: “Closest Black Hole or no Black Hole at all…?”</td><td></td></tr>
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[Visual starts]

1. In 2020, an ESO-led team of astronomers published a paper on HR 6819 – a system with two stars only 1000 light-years away…

Thomas Rivinius: “Looking at the spectra it was immediately obvious that there was something wrong with the system.”

One of the stars appeared to be closely orbiting an invisible object, with the second star in a much wider orbit.

The team thought this invisible object could only be a black hole, the closest to Earth ever found!

Really?

Among others, a group of researchers from KU Leuven in Belgium challenged their results…

A scientific dispute, only to be settled by…
…more science!</td><td>00:00

Text plate: Thomas Rivinius — Paranal Science Operations (ESO)</td></tr>
<tr><td>New ESOcast intro

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3. Both teams agreed there were two sources of light in the system. The question was whether they were far apart or orbited each other closely. Julia Bodensteiner: “We proposed that this Be star is not an outer star that is unrelated to the system but it is actually moving in orbit with this B-type star (...).” Julia Bodensteiner: “But the star that was thought to be a normal B-type star is actually a stripped star (so) of much lower mass …”	Text plate: Julia Bodensteiner — Former PhD student (KU Leuven) and ESO Fellow
4. Abigail Frost: “One star can steal material from the other star, stripping it of its outer layers and its atmosphere and that’s essentially how you go from two fairly normal stars to one which has gained mass and one which has been stripped of its mass.” This would make HR 6819 a rare “vampire” two-star system but with no black hole. Thomas Rivinius: “When I realised that this was indeed a viable hypothesis and it was at least as likely as ours that made me sweat a little.”	Text plate: Abigail Frost — Postdoctoral Researcher (KU Leuven)
5. So how could this dispute be settled? Thomas Rivinius: “We needed interferometric data and we all knew there’s only one facility in the world that can get that.” Julia Bodensteiner: “It had to be the VLTI and we had already prepared a proposal when Thomas and his team contacted us and we were very happy about that. We don’t need to ask for the same data twice on such a competitive telescope. It makes no sense. ” Thomas Rivinius: “(...) It was quite obvious that we should work together and that’s why I proposed it. The scientific competition is not about who is getting the data. The scientific competition is on the basis of the data.”	

6. The joint Leuven-ESO team used two instruments: MUSE on the Very Large Telescope (VLT) and GRAVITY on the VLT Interferometer. Julia Bodensteiner: “We wanted to see if there are two sources that are far apart from each other. What MUSE does is that (...) it provides you with a combination of photometry and spectroscopy. (...) For our purpose this was the perfect tool (to use because) it would tell us not only if there are two sources but we could get the spectra as well and this would immediately tell us if they are far enough apart to resolve them, (...) and how far apart are they.” Thomas Rivinius: “GRAVITY provides additional spectroscopic information. It actually allowed us to identify which star is which. (...)” Abigail Frost: “We got the MUSE data first (...) and then we didn’t see the wide companion (...) We needed the GRAVITY data (...) to check if there were two bright stars within the GRAVITY range and that was the final piece of the puzzle.” Antoine Mérand: “I joined (I think) the latest. Abigail was using a code I wrote to analyse the GRAVITY data and contacted me to make sure that we explore all the possible ways we can interpret the data.”	 Text plate: Antoine Mérand — VLTI Program Scientist (ESO)
7. How did you feel about collaborating despite your opposing theories? Antoine Mérand: “I think it’s nice to see in this particular case. (...) sometimes it doesn’t go this way. (...) Even though everybody said this is the right thing to do and you can advance science (...) – people are emotionally invested. They will maybe be a little bit blinded by this investment. ” Julia Bodensteiner: “(...) The important thing is	

to focus on the science. To try (...) not to look for who's right and who's wrong but to think of how we can advance the question that is on the table." Abigail Frost: "It was (...) a win-win situation. Either way we find something pretty cool. On the one hand we confirm the existence of the nearest stellar black hole to Earth (...), on the other we find this really exciting and difficult to catch evolutionary stage of a massive binary stellar system."	
8. So who was right…? Thomas Rivinius: "I was the one observing myself so I (...) saw it the very minute it came in." Thomas Rivinius: " (...) Looking at the data as it was fresh out of the instrument I realised that there was no distant companion. That (...) made it very likely that Julia's and Abi's hypothesis was right. "	
9. Any hard feelings? Thomas Rivinius: "Personally I would have wanted my interpretation to be correct and scientifically I have to admit that this interpretation is the far more interesting option. Black holes are honestly rather boring objects – in particular if they're quiet, in quiescence – they don't do anything." Julia Bodensteiner: "(...) I would have been very fine with this original interpretation of that system. In our community people are looking for these quiescent black holes which are (...) very difficult to detect. They don't find them anywhere. " Antoine Mérand: "The whole story of this project is that there were competing explanations (...) but they made some prediction: If the hypothesis of the black hole is this way then this is what we should see if	

we observe with this particular instrument. And if there's no black hole we will see something different. (...) The observations (...) were really designed saying we can test which hypothesis is the most likely. And in the end we have a very definite answer."	
10. So what's next? Thomas Rivinius: "For the original question of the nature of the system (...) we have reached a satisfying conclusion. But now there's a lot more to learn about it like the precise masses that are involved, what was the original star, what is the future of the stars and how is this coming about." Julia Bodensteiner: "The stripped star scenario is very exciting!" Julia Bodensteiner: "Previously we've often studied binary systems (...) before they have interacted (...). But in that system (...) we can learn something about the physics that occurred during the interaction and also about the outcome which will then also help us to model the future evolution of the system." Abigail Frost: "This collaboration between our two teams is continued and our proposal has been accepted to continue monitoring the system with GRAVITY."	
Thomas Rivinius: "I think it is very important that the public understands the process of science – that it's not a machine where you crank the lever and the truth comes out but that it is a method of discourse which has an agreed upon and tested method to tell you what likely works and what likely doesn't. (...) We live in times where the societies look towards science for guidance and under these circumstances I think it is really of great importance that the public understands how science works."	

[Outro]	*Produced by ESO, the European Southern Observatory.* *Reaching new heights in Astronomy.*
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