



Contribution ID: 827

Type: **Talk in the parallel session**

Can different black holes cast the same shadow?

Tuesday 6 July 2021 10:30 (20 minutes)

We consider the following question: may two different black holes (BHs) cast exactly the same shadow? In spherical symmetry, we show the necessary and sufficient condition for a static BH to be shadow-degenerate with Schwarzschild is that the dominant photonsphere of both has the same impact parameter, when corrected for the (potentially) different redshift of comparable observers in the different spacetimes. Such shadow-degenerate geometries are classified into two classes. The first shadow-equivalent class contains metrics whose constant (areal) radius hypersurfaces are isometric to those of the Schwarzschild geometry, which is illustrated by the Simpson and Visser (SV) metric. The second shadow-degenerate class contains spacetimes with different redshift profiles and an explicit family of metrics within this class is presented. In the stationary, axi-symmetric case, we determine a sufficient condition for the metric to be shadow degenerate with Kerr for far-away observers. Again we provide two classes of examples. The first class contains metrics whose constant (Boyer-Lindquist-like) radius hypersurfaces are isometric to those of the Kerr geometry, which is illustrated by a rotating generalization of the SV metric, obtained by a modified Newman-Janis algorithm. The second class of examples pertains BHs that fail to have the standard north-south Z_2 symmetry, but nonetheless remain shadow degenerate with Kerr. The latter provides a sharp illustration that the shadow is not a probe of the horizon geometry. These examples illustrate that nonisometric BH spacetimes can cast the same shadow, albeit the lensing is generically different.

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Session Classification: Gravitational Lensing and Shadows

Track Classification: Precision Tests: Gravitational Lensing and Shadows