Lecture 23 : Black Holes II

Chandrasekhar once remarked that - "The black holes of nature are the most perfect macroscopic objects there are in the universe: the only elements in their construction are our concepts of space and time."

The truth of this statement lies in the amazing history of how the present theory of black holes came into existence. One of the most remarkable developments in physics in the later part of the twentieth century, the formulation depended entirely on considerations of theoretical physics and abstract mathematics, without any observational corroboration (an essential direction of investigation that has opened up only in the last few years).

As we saw in Lecture 21, in 1939 Oppenheimer and his student, Snyder, made the spectacular discovery that if a star contracts to the critical radius, and becomes BLACK, it will continue to collapse till it disappears - all that will be left is a Black HOLE! This raised the following fundamental question, "What is inside a black hole?" This question was answered emphatically by Sir Roger Penrose in 1965. He showed in a mathematically exact manner that if a black hole forms, there must be a space-time singularity inside it. He was awarded the Nobel Prize in 2020 for this profound discovery. This was followed by a series of spectacular theorems - the "No Hair Theorems" - concerning the attributes of black holes. And then came, in 1974, the great discovery by Stephen Hawking that black holes will emit radiation, after all! This lecture will attempt to describe these great discoveries in simple terms.

Text Books & Resource Material :

1. S. Weinberg, 1972, ***Gravitation and Cosmology***, John Wiley & Sons
2. C. W. Misner, K. S. Thorne, J. A. Wheeler, 1973, ***Gravitation***, Princeton University Press
3. L. D. Landau & E. M. Lifshitz, 1975, ***Classical Theory of Fields (Chapters 10-13)***, Pergammon Press
4. S. L. Shapiro & S. A. Teukolsky, 1983, ***Black Holes, White Dwarfs and Neutron Stars (Chapter 12)***, Wiley-Interscience
5. R. M. Wald, 1984, ***General Relativity***, University of Chicago Press
6. R. M. Wald, 1992, ***Space, Time and Gravity : The Theory of Big Bang and Black Holes***, University of Chicago Press
7. S. D. Kawaler, I. Novikov, G. Srinivasan, 1997, ***Stellar Remnants (Chapter 3)***, Springer
8. S. Chandrasekhar, 1999, ***Mathematical Theory of Black Holes***, Oxford University Press
9. E. F. Taylor, J. A. Wheeler, 2000, ***Exploring Black Holes***, Addison Wesley Longman
10. E. Gallo & D. Marolf, 2009, ***Resource Letter BH-2 : Black Holes***, Am. J. Phys., 77 (4), 294

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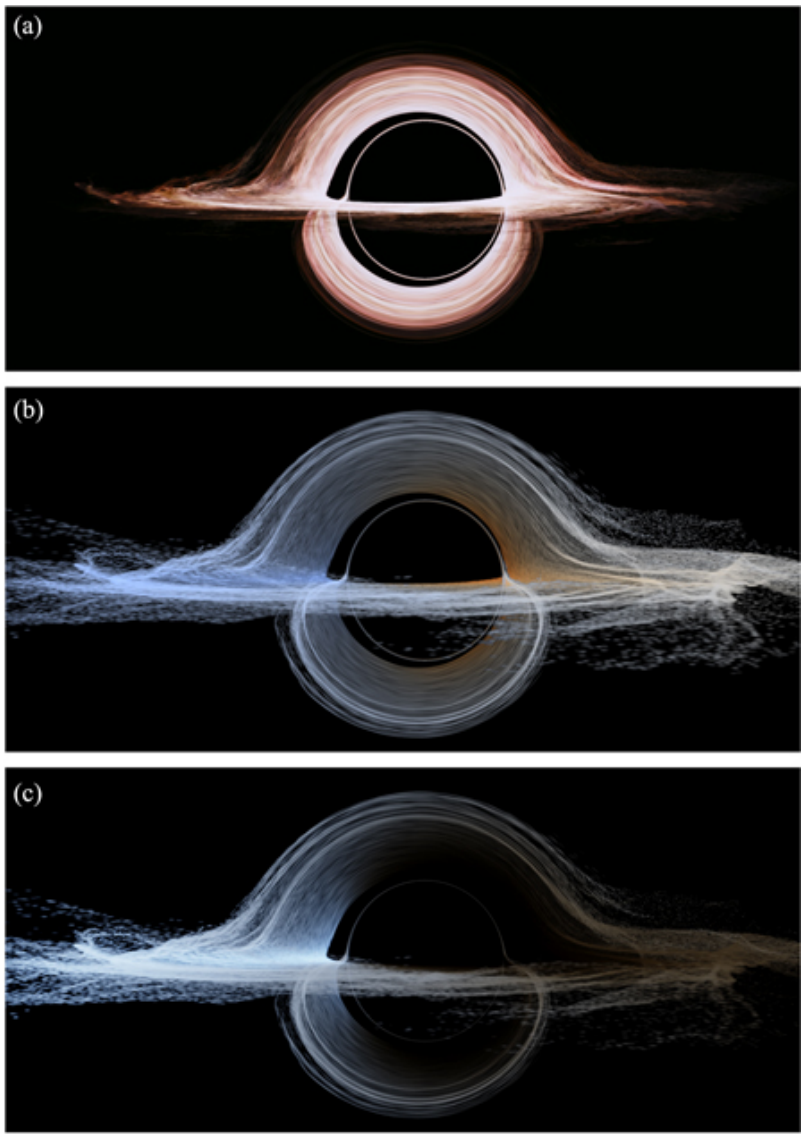
Astronomy & Astrophysics : An Introductory Survey

A lecture series by Prof. G. Srinivasan

A 'Golden Jubilee Celebration' Event of the Astronomical Society of India

Lecture 23 : Black Holes II

[Supplementary Material : Dr. Sushan Konar]



Black Hole simulation for 'Interstellar'

Visualising the regions around a Black Hole is not an easy undertaking. Undoubtedly, one of the most extensive simulations to do so has been for the 2014 Hollywood film *Interstellar*.

Scientists working for the visual effects studio, DNEG, teamed up with Kip S. Thorne to generate realistic images for regions around a Black Hole for *Interstellar*. The scientific study behind the work, inclusive of details of the computer code, has later been published in the journal *Classical and Quantum Gravity*.

The adjoining images show a moderately realistic accretion disk (a), with its colours shifted due to Doppler and gravitational effects (b), and with its brightness shifted - the way it would truly appear to an observer near a Black Hole.

Of course, the image we are familiar with from the film looks somewhat different. It's because of the inclusion of lens flare (additional effect that would have been there had such a region been photographed by a real camera).

Figure Credit : O. James, E. von Tunzelmann, P. Franklin, K. S. Thorne, 2015, Class. Quantum Grav., 32, 065001

General Interest Reading :

1. K. S. Thorne, 1994, ***Black Holes & Time Warps***, W. W. Norton & Company
2. K. Bird & M. J. Sherwin, 2006, ***American Prometheus: The Triumph and Tragedy of J. Robert Oppenheimer***, Vintage
3. S. Hawking, 2016, ***Black Holes : The BBC Reith Lectures***, Bantam
4. O. James, E. von Tunzelmann & P. Franklin, 2015, ***Visualizing Interstellar's Wormhole***, Am. J. Phys., 83, 486

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