



Radiowave images show filamentary structures near the black hole at the centre of our Galaxy.

## COSMOLOGY

# Enigma at the heart of the Universe

Mario Livio enjoys a tour of modern astronomy that speculates on how black holes drive cosmic evolution.

“The road of life twists and turns and no two directions are ever the same. Yet our lessons come from the journey, not the destination.” So wrote US novelist Don Williams Jr. Caleb Scharf’s engaging *Gravity’s Engines* demonstrates the truth in this statement.

Scharf speculates that black holes rule everything in the cosmic landscape — from the large-scale structure of the Universe to life. Using rich language and a brilliant command of metaphor, he takes on some of the most intricate topics in theoretical and observational astronomical research. He weaves a wonderfully detailed tapestry of what modern astronomy is all about, from the complexities of cosmic microwave background studies to the X-ray mapping of galaxy clusters.

Scharf begins with the basics: an excellent overview of the history of astronomy and astrophysics, and illuminating examples to explain how the complete cosmic picture is deciphered. His discussion of how gravity shapes the Universe and determines its

evolution is admirably clear, and covers the early history of X-ray and radio astronomy, as well as some of the perplexing objects (such as compact X-ray sources) discovered using new observational techniques.

He handles the complex physical processes that occur in the vicinity of black holes with aplomb and attention to detail. And he gets to the crux of the feedback process between the growth of mass-accreting black holes and the evolution of stellar bulges in their host galaxies.

I feel that Scharf begins to overstate his argument in his attempts to solidify the case



**Gravity’s Engines:  
How Bubble-Blowing  
Black Holes Rule  
Galaxies, Stars,  
and Life in the  
Cosmos**  
CALEB SCHARF  
*Scientific American*:  
2012. 272 pp.  
\$26/£18.99

for supermassive black holes as “regulators” of star formation in galaxies. There is no doubt that central black holes and the stellar bulges that surround them (when they exist) co-evolve. But the outer disks of spiral galaxies such as Andromeda are hardly affected at all by the presence of supermassive black holes.

I have quibbles, too, with the passages in which Scharf attempts to support his argument that black holes are the main engines driving everything from re-ionization and cosmic star formation to galactic evolution and the emergence of life. For instance, he argues that stellar-mass black holes played a crucial part in the cosmic phase transition associated with the re-ionization of the intergalactic medium. But the jury is still out on this particular process. The main agent of re-ionization may be ultraviolet photons from galaxies — a point that looks likely to be verified soon through observation.

Scharf also uses the story of our own Galaxy, the Milky Way, and statistical information collected through the citizen-science project Galaxy Zoo, to depict the “duty cycles” of activity and calm in the process of accretion onto supermassive black holes. He appeals to these to circumvent the apparent discrepancy between the idea of black holes as regulators and the fact that the Milky Way’s central black hole is currently inactive.

All this culminates with his intriguing statement that “the entire pathway leading to you and me would be different or even nonexistent without the coevolution of galaxies with supermassive black holes and the extraordinary regulation they perform”. Scharf admits that many steps remain uncertain and that numerous questions have yet to be answered. But he proposes that because the cosmic and galactic environments leading to the rise of complexity and life are part of black holes’ galactic evolution, it is reasonable to ask what special things link us directly to that history.

However, I feel less certain than Scharf about the answer. He explains that the tight correlation between the masses of supermassive black holes and of stellar bulges at galaxies’ centres reveals a co-evolution. It is equally certain that feedback from supermassive black holes had an important role in the ensuing star-formation history in the bulges of galaxies. But was this the key factor in determining whether life-bearing planets should exist or not? I doubt it. Still, the idea makes for a very interesting journey. ■

**Mario Livio** is an astrophysicist at the Space Telescope Science Institute in Baltimore, Maryland. His blog, *A Curious Mind*, explores science, art and the links between them. His upcoming book is *Brilliant Blunders*, to be published in May 2013. e-mail: [mlivio@stsci.edu](mailto:mlivio@stsci.edu)