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ROTATING BLACK HOLES TIED TO HUGE ENERGY BURSTS

Could the Milky Way galaxy -- in which our solar system is but a tiny speck -- change from its quiet, millpond existence into a turbulent, churning dynamo, expelling matter and energy trillions of miles into space? Has it done so in the past? Will it happen again?

Dr. Minas Kafatos of George Mason University, Fairfax, Va., and NASA's Goddard Space Flight Center, Greenbelt, Md., says such events are possible if his theory that massive rotating black holes, millions or billions of times more massive than the Sun, are causing the enormous release of energy from the centers of active galaxies and quasars.

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Quasars themselves are considered mysterious, even baffling objects to astronomers. They emit vast amounts of energy and are believed to be the most distant objects observed, some possibly as far as 10 billion or more light-years away, at the very edge of the observable universe.

Recently, radio observations by Drs. Kafatos, R.W. Hobbs, S.P. Maran and L.W. Brown of Goddard, have shown that the central component of Cygnus A, a "nearby" radio galaxy some billion light-years away which puts out as much energy in radio waves as a hundred billion Suns would emit in visible light, is similar in many respects to quasars.

The theory that there are massive holes at the centers of active galaxies or quasars is not new, but the concept that the black holes powering the active nuclei are rotating is new.

What Kafatos says is that it is theoretically possible to extract energy from the region surrounding the black hole, called ergosphere, by processes known in the Theory of General Relativity as "Penrose Processes." According to this idea, matter falling toward the surface of the rotating black hole can break up, with one portion being injected into the black hole at half the speed of light and never emerging while the other portion would fly out with more energy than the total object had when it entered the ergosphere.

The energy it gains is transferred from the rotational energy of the black hole. In effect, the matter ejected gains energy by slowing down the spinning of the black hole. The spinning process depends critically on the black hole rotating rapidly enough.

Kafatos and Darryl Leiter of George Mason University recently studied Penrose Processes involving elementary particles in the ergospheres of what they believe are rotating black holes. What is required in these processes is a supply of very high energy light waves, known as gamma rays, entering the ergosphere.

The results of the theory proposed by Kafatos and Leiter can be summarized as follows: the gamma rays enter the ergosphere, slam into protons and are turned into electrons and positrons. The two new particles then are picked up by the rotation of the black hole. The proton is sucked down the black hole, never to return, while the electron and positron are ejected by the rotation with much more energy than the original gamma ray possessed (see drawing on page 6).

The details of the theory are under study by Kafatos. The Penrose Processes are continuous, with matter and gamma rays bombarding the swirling hole, detaching energy and streaking out of the galaxy.

The gamma rays are formed by the very hot accretion disk of swirling gases that form around the hole. However, there must be sufficient gaseous mass available in the galaxy to continue the processes, otherwise, the black holes, like gigantic vacuum cleaners in space, would empty the center of the galaxy of the material necessary to cause violent activity in the galaxy.

"Energy extraction would become inefficient once the gas falling into the black hole becomes depleted or the spin of the black hole is reduced," says Kafatos. "That's why we observe the most violent events in the distant past, billions of light years away from Earth, because in those early days of the universe there was more gaseous mass available," he adds.

Three active galaxies, including a radio galaxy and quasar 3C273 (famous because of its brightness and variability) have been examined by Kafatos via data received from radio astronomy telescopes and from NASA's Small Astronomy Satellite-2, launched in 1972. The Kafatos studies indicate the theory of the Penrose Processes may be correct. All of these galaxies emit a majority of their energy in gamma rays, a surprise in view of the fact that it is very difficult to produce gamma rays in nature. In addition, the three active galaxies examined radiate radio waves as predicted by the theory, says Kafatos.

Kafatos expects the theory can be confirmed in the early 1980s when the NASA Gamma Ray Observatory is placed in orbit by the Space Shuttle. Present spacecraft are not sufficiently advanced to "look" far enough into space at other active galaxies or quasars.

The theory also explains the relative inactivity of nearby normal galaxies. But even they could flare up if sufficient gaseous material were found, for example, by a chance breakup of a cluster of thousands of stars near the black hole. The gaseous material could then be drawn into the middle of the galaxy by the massive black hole which would cause the nucleus of the galaxy to explode with activity. Such an event could happen to any normal galaxy containing a massive black hole.

"Maybe our own Milky Way galaxy flared up like that millions of years ago as a result of such a chance event. In fact, it could flare up again in the future," Kafatos says.

