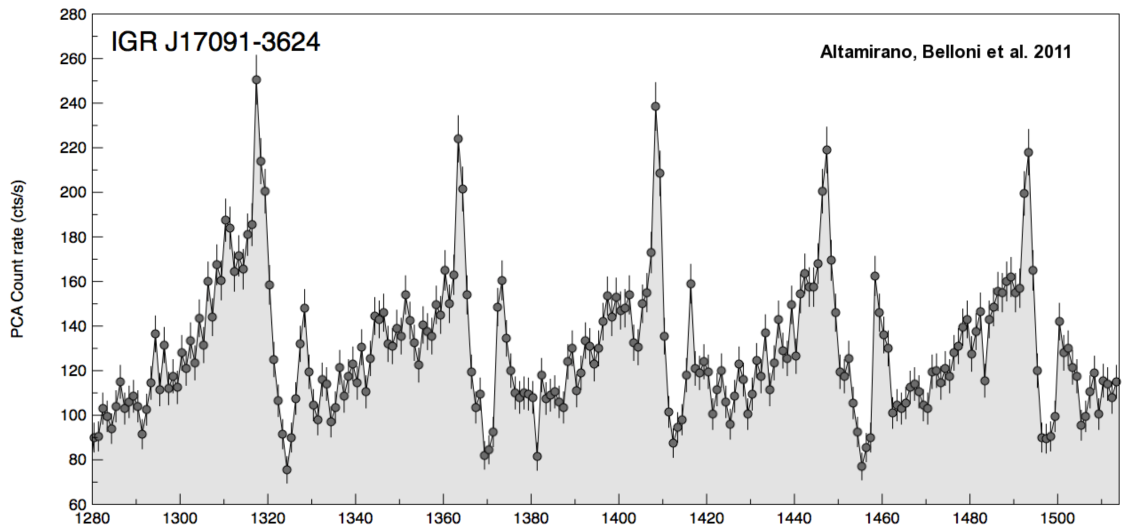
Measuring the Speed of Gas Near a Black Hole



NASA's RXTE spacecraft recently recorded rhythmic x-ray flashes from the black hole candidate called IGR J17091-3624. The black hole is a member of a binary system that combines a normal star, with a black hole that may weigh three times the sun's mass. That is near the theoretical mass boundary where black holes become possible. The system is located in the direction of the constellation Scorpius between 16,000 light-years and 65,000 light-years from Earth.

Gas from the normal star streams toward the black hole and forms a disk around it. Friction within the disk heats the gas to millions of degrees, which is hot enough to emit X-rays. The very fast, cyclical variations in the x-ray light may be occurring near the black hole's event horizon - the point beyond which nothing, not even light, can escape.

Problem 1 – The RXTE satellite measured the x-ray intensity of this star system hundreds of times an hour. The plot above (called a light curve) shows how this brightness changes over time. Each division is 10 seconds long. From this figure, what is the average period of the brightness changes in seconds?

Problem 2 – The radius of a 3-solar mass black hole is about 10 kilometers. If the flickering has to do with the orbital motion of gasses at a distance of 15 kilometers, how fast is the gas orbiting the black hole in kilometers per second?

http://www.nasa.gov/topics/universe/features/black-hole-heartbeat.html

NASA's RXTE Detects 'Heartbeat' of Smallest Black Hole Candidate
12.15.11

Problem 1 – The RXTE satellite measured the x-ray brightess of this star system hundreds of times an hour, and the plot above shows how this brightness changes over time. Each division is 10 minutes long. From this figure, what is the average period of the brightness changes in seconds?

Answer: With the help of a millimeter ruler, the horizontal scale is about 1.7 seconds/mm so the peaks are separated by 27mm, 26mm, 22mm, 27mm or 46, 44, 37 and 46 seconds respectively. **The average period is 43 seconds.**

Problem 2 – The radius of a 3-solar mass black hole is about 10 kilometers. If the flickering has to do with the orbital motion of gasses at a distance of 15 kilometers, how fast is the gas orbiting the black hole in kilometers per second?

Answer: We know how long it takes the gas to go once-around so now we need the distance traveled along the circumference of the orbit with a radius of 15 km.
C = 2 (3.14)(15 km) = 93.6 km. Then the speed is just the distance divided by time:
S = 94 km/43 seconds so **S = 2.2 km/sec**.

The graph below is another flickering black hole candidate. How fast does the gas travel around this black hole?