Re: Measuring the mass of a black hole

Source: http://sci.tech−archive.net/Archive/sci.physics/2007−02/msg03006.html

- *From*: "Paul W" <1337usr@xxxxxxxxx>
- *Date*: 18 Feb 2007 08:37:52 −0800

On 17 Feb, 16:50, "PD" <TheDraperFam...@xxxxxxxxx> wrote:

> On Feb 17, 9:42 am, "Paul W" <1337...@xxxxxxxxx> wrote:
>
> > On 15 Feb, 16:59, "PD" <TheDraperFam...@xxxxxxxxx> wrote:
> >
> > > On Feb 15, 4:06 am, "Paul W" <1337...@xxxxxxxxx> wrote:
> >
> > > > Hello,
> >
> > > > When a black hole candidate is discovered,
> > > > how do you actually measure
> > > > it's mass? Are there different techniques for
> > > > doing it?
> >
> > > > Thanks,
> > > > Paul W.
> >
> > > Typically by watching stuff orbit around it.
> > > Watching the Moon's orbit is how we know the mass of the
> > > Earth, and
> > > watching the Earth's orbit is how we know the mass of the
> > > Sun.

PD

Are there any formulae to use for this?

For the moon orbit and the earth orbit, the Newtonian approximation works very well. I won't do the same for black holes, because the relativistic notation is dense.

For the Newtonian case, the force between two objects of mass M and m is
GMm/r^2
and Newton's law of motion is F=ma, where m is the mass of the orbiting object
and the left hand side is what we just wrote down
GMm/r^2 = ma
and if we approximate the orbit as a circle, then we also know the acceleration
4*pi^2*r/T^2, where r is the radius of the orbit and T is the time for one orbit.
Putting all this together we have
GMm/r^2 = 4m*pi^2*r/T^2
The mass of the orbiting object is m and it cancels out, leaving
M = 4*pi^2*r^3/(G*T^2)
So if we know the distance from the Earth to the Moon (by parallax, say), and we measure T, then we've measured the mass of the Earth M.

The constant ratio between r^3 and T^2 is fairly famous, being one of Kepler's laws.

I've made a number of approximations in the above −− the moon doesn't really travel in a perfect circle, the Earth also orbits a center of gravity, etc −− but this is good enough for a 1% accurate answer.

PD

What if there is a gas cloud or an accretion disc around the measured object? Will this still apply?

[Thanks for all your help, and sorry for asking so many questions =)]

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