CALIFORNIA STATE SCIENCE FAIR
2008 PROJECT SUMMARY

Name(s)
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Project Number
S1607

Project Title
Are Black Hole Mass Estimates Too Large?

Abstract

Objectives/Goals
The periodicity of X-ray bursts from Active Galactic Nuclei (AGN) appears to be dependent on the recovery interval between mass-infall events. This recovery interval is proportional to the speed at which information of the event propagates (speed of sound) and the mass of the central black hole. This project seeks to determine whether the assumed speed of information propagation in an accretion disk can affect mass estimations of the central black hole.

Methods/Materials
A computer simulation was developed to model X-ray emissions from AGN for six different speeds of information propagation (c/100, c/10, c/6, c/3, c/2, and c/1, where c is the speed of light). For a real-time equivalent of one month, the simulation was run with each different speed of propagation and a variety of initial energy states. To find the effect on mass estimation, the simulated light curves were analyzed using a mass-variance relationship.

Results
It was found that lower speeds of propagation had longer time intervals between events and resulted in lower estimates of black hole mass. Additionally, Fourier transforms of the light curves implied a linear relation between speed of propagation and x-ray burst periodicity. The variation time scales are comparable to observed data.

Conclusions/Discussion
The results show that the variability of X-ray emissions is dependent on the speed of perturbations within the disk. The results also show that estimates of black hole mass are reduced when based on slower speeds of sound. It follows that current approximations of central object mass are overestimates by at least a factor of three because they assume that perturbations travel at the speed of light c, while the speed of propagation has an upper limit of c/3. Given the generality of the simulation, more accurate estimates of black hole mass can be calculated by correcting for the speed of sound in accretion disks.

Summary Statement
This project used a computer simulation of AGN X-ray emissions to show that the speed of information propagation in an accretion disk can affect mass estimations of the central black hole.

Help Received
This project was suggested by Dr. Ran Sivron to me and two other students, Elliott Jin & Benjamine Liu in August 2007. I worked with these two students on the project until September 2007. I have spoken with Dr. Sivron twice since September and he referred me to scientific papers in this field.