CALIFORNIA STATE SCIENCE FAIR
2002 PROJECT SUMMARY

Name(s)

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Project Number

22592

Project Title

The Mass Profile of the Cluster A2029 Revealed by the Chandra X-Ray Telescope: Implications for Theories of Dark Matter

Abstract

Objectives/Goals

This research aims to resolve a longstanding question of modern astronomy. A large discrepancy between the dynamical mass and luminous mass of cosmic structures has led to the widely held belief that at least 90% of the universe's mass is due to dark matter - a form of matter that exerts a gravitational force but is otherwise unobservable. The identity and characteristics of dark matter are important cosmological questions that have direct bearing on properties of cosmological formation. Is one of the proposed theories of dark matter-Cold Dark Matter (CDM)-supported by the wealth of high-quality X-ray data collected by the Chandra X-ray Observatory? CDM claims that dark matter consists of a presently undiscovered particle that is virtually non-interactive (except gravitationally) and was initially in a near-motionless state. We hypothesize that there will be a close correspondence of the measured radial mass and density profiles with the theoretical predictions from the large-scale simulations of a CDMx universe conducted by Moore et al.

Methods/Materials

A computer with a C++ compiler and image data of galaxy cluster Abell 2029 from the Chandra X-Ray Observatory were all the materials needed. Data from A2029 was retrieved from the Chandra Public Dax Archive. The unprecedented spatial and spectral resolution of Chandra allow us to plot the radial profiles of the temperature and electron density of the X-ray emitting gas that fills the potential well of A2029 at small radii-less than 200 kpc-with unprecedented precision. Based on the equations of hydrostatic equilibrium, the radial mass profile is calculated and fit to a power law curve of the form M(<r) = k_1(k_2 + r)^{beta}, which gives a mass density profile that goes as rho(r) ~ r^{-alpha} where alpha = 3 - beta. The value of alpha is crucial in differentiating between different models of dark matter and cosmological formation; the Moore simulation of the CDM paradigm predicts that alpha = 1.5.

Results

Alpha (the slope of the radial mass density profile) = 1.28 ± .14; the determination of this value was the goal of this research.

Conclusions/Discussion

We conclude that the CDM paradigm is accurate. With this novel constraint, it is further concluded that the method of determining the contribution of luminous matter to mass in non-dark matter dominated structures is in need of improvement because of discrepant findings of alpha in such situations.

Summary Statement

This research is an X-ray deprojection analysis of Chandra data that provides validation of the Cold Dark Matter Paradigm on cluster scales - 10 to the 15th solar masses.

Help Received

Worked at the University of California, Irvine, under Dr. David A. Buote