Rotation Curve Modeler & Scholarly Observed Celestial Measurements For Arbitrary Galaxies

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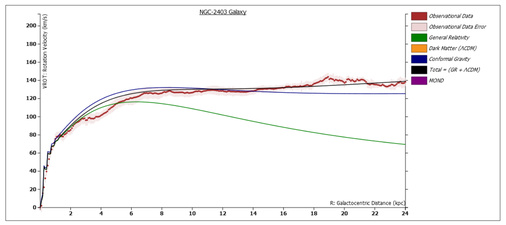
Introduction

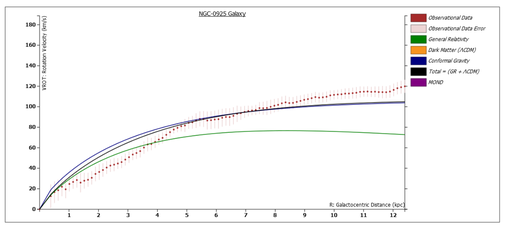
In order to model galaxies, researchers must first sift through peer-reviewed articles and gather galactic data one-by-one. Then astrophysicists would model the galaxies in programs like MATLAB or Mathematica, but there doesn't exist a singular tool to expedite this process in a universal format. This project intends to solve both of these problems. First, building a public database to act as a central repository for galactic parameters and observed velocity data. Second, providing a tool to generalize the work being done on galactic modeling. The website consists of these two major components.

Scholarly Observed Celestial Measurements (SOCM) serves as both a central database and API (Application Programming Interface) for researchers and programmers alike. SOCM includes galactic data collected on 112 galaxies, including the peer-reviewed measurements of stars contained therein. Users may submit new measurements to the SOCM administrator for approval. Programmers may pull from the SOCM API to use the data for other applications.

The Rotation Curve Modeler (RoCM) serves as a tool to model the rotation of star clusters around the center of a galaxy. It's purpose is to test all existing galactic models against the observational data for the specified galaxy. With observable data as the input (via SOCM), any arbitrary galaxy can be imported into the tool. The tool plots observational data and multiple galactic models together as a graph, and enables users to import their own galactic models to test against existing theories. Parameter value sliders allow users to control free fitting parameters within their models with real-time visual feedback in the generated graph. Users may also generate a Rotation Curve Simulation (RoCS) to view their models against the data in two-dimensional rendering.

Example Rotation Curves





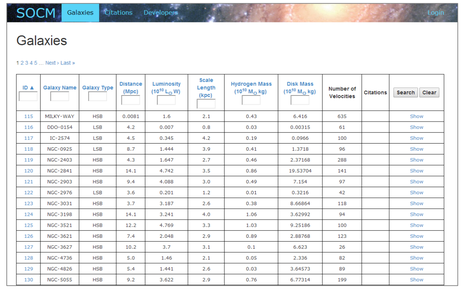
Design

SOCM is a Ruby on Rails application with a PostgreSQL relational database utilizing Twitter bootstrap for webpage views. The website consists of a landing page, pages for the galaxies, citations, and developer information, as well as pages for administrative functions.

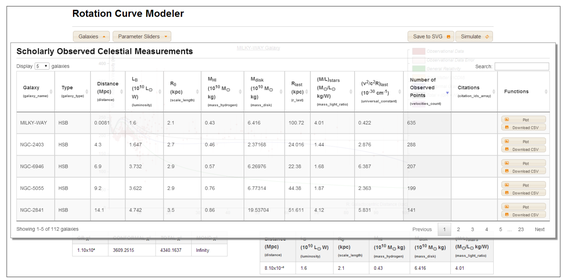
The galaxies page consists of a paginated table containing the relevant higher-level information of galaxies, including their relative distance from our sun, luminosity, scale radius, mass of the disk, and more. Selecting one of these tables allows users to view the collected velocity measurements of stars for this galaxy, including respective distances from the center of the galaxy, the observed rotation velocity, and the calculated errors of these measurements. The citations page lists the papers from which these measurements are referenced.

RoCM and RoCS utilize the API provided by SOCM, querying for these high-level galaxy parameters and the galaxies' constituent velocity measurements. Responses from the API come in the form of JSON (JavaScript Object Notation) objects, which can be parsed and utilized for application purposes.

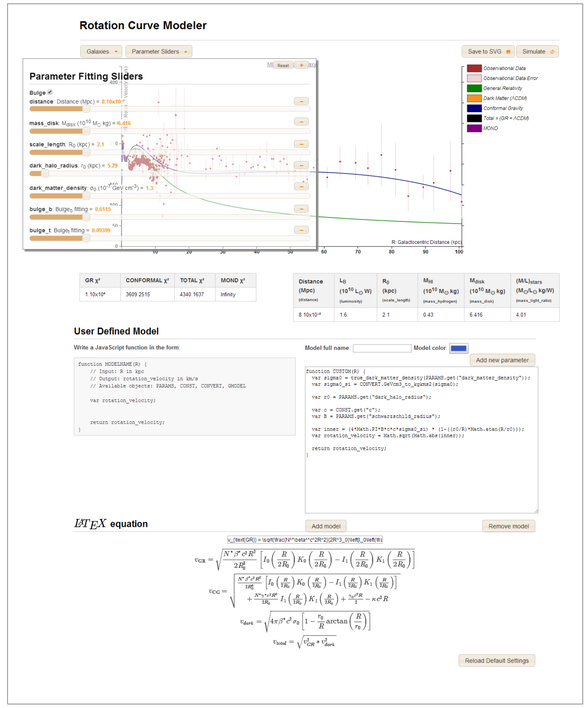
SOCM Galactic Database



Accessing SOCM Data from RoCM



Rotation Curve Modeler



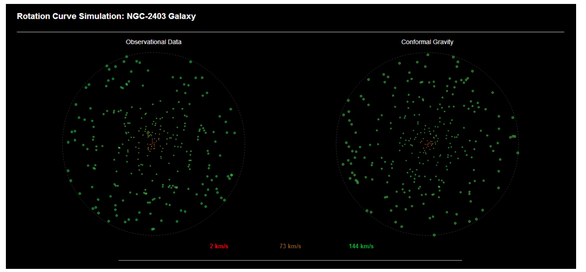
Implementation

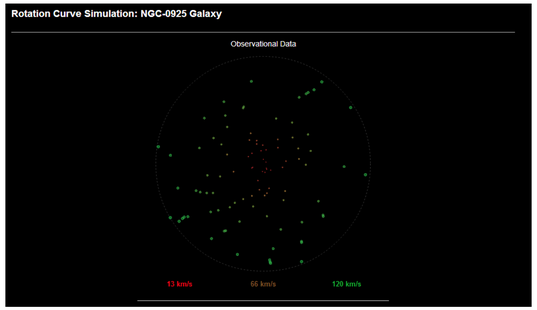
RoCM is also a Ruby on Rails application utilizing various JavaScript libraries and uses SOCM as its service layer. The single-page website consists of the following: quick-reference table of SOCM (to select galaxies to plot), a table of sliders to manipulate values within galactic models (for parameter fitting purposes), a rotation velocity over galactocentric distance graph to plot models against collected data, a button to save the graph as an SVG (Scalable Vector Graphic), a button to send the selected model to RoCS, a means of import a user defined model to graph, and a section for users to import their models in LaTeX format (for better understanding the behavior of parameters within each equation). These tools all contribute to the powerful functionality we've provided in RoCM.

Much of the heavy-lifting on the site is performed by D3, a JavaScript library for "manipulating documents based on data." [1] Our application uses asynchronous JavaScript calls (or *AJAX calls*) to pull data from SOCM. The D3 library then helps us translate and manipulate that data to create the rich graphs and tables provided in RoCM.

Rotation Curve Simulation

RoCS provides a way to visualize the spin of the galaxy in question. The user can simulate either just the observational data, or a specified model against the data. The color scale represents the relative minimum and maximum velocity for the stars around the center of the galaxy. The scale helps recognize when the rotation curve simulation of a model doesn't match up with the observational data (see the RoCS webpage for the full rotation curve simulation).





Conclusions

The hope is that astronomers will use SOCM to upload observational data in one central location. Astrophysicists then can use RoCM to test that data against several galactic models to finally understand the dynamics of galaxies.

We would like to thank Dr. James G. O'Brien for his work on the rotation curve problem using conformal gravity. His work influence the successful outcome of this project.

We are pleased to announce that SOCM is open to the public at socm.herokuapp.com, where users can now view our database of collected measurements and developers may use our API endpoints to use in their own endeavors. RoCM is hosted at rotationcurve.herokuapp.com and will be shortly moved to rotationcurve.wit.edu / rotationcurve.org. Each project is a contribution to the open source community and can be found here: https://github.com/RoCMSOCM

1. Bostock, Mike; "Data-Driven Documents"; Last updated: 2013; Last visisted: July 28, 2014; http://d3js.org/