Investigating the Gas Chemistry of Protoplanetary Disks

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Abstract

Using Interactive Data Language (IDL), an established data visualization software, I analyze infrared spectroscopic observations of protoplanetary disks. The observations are taken with the Very Large Telescope (VLT) in the Atacama Desert of Chile using the Cryogenic Infrared Echelle Spectrograph (CRIRES). Observing protoplanetary disks, or the gas and dust around early stars, gives us insight as to what material surrounds early stars, and since planets form in the protoplanetary disk of the star, investigating the chemical composition of protoplanetary disks allows us to probe the material that will eventually make up the planets around a certain star. Planets whose origins and compositions we would like to better understand include the recent discoveries of "super-Earths." Observing these super-Earths gives us minimal information as to what they are composed of, but observing protoplanetary disks can help us better understand the origins of the atmospheres and interiors of these planets(Mandell 2012).

Introduction

Protoplanetary disks are rotating ring-shaped disks of gas and dust that surround a y0ung star. As one of the youngest stages of a solar system, understanding protoplanetary disks can deepen our understanding of more developed systems. By understanding the gas chemistry of protoplanetary disks, we can understand the primordial materials that later make up the planets, their atmospheres, and objects in a solar system.

We use CRIRES and the VLT in northern Chile to obtain raw infrared spectroscopic data. Unfortunately, the VLT is a ground based telescope which results in a set of problems induced by atoms in the earth's atmosphere absorbing and emitting light in the infrared frequency ranges of about 750 nm --1 mm..

Reducing Data

Telluric Effects

Observing from Earth's ground means we must look through Earth's atmosphere. Earth's atmosphere contains, among other elements and molecules, many water molecules. These molecules absorb light at specific frequencies and obscure our view past the atmosphere. Unfortunately, the only way to truly eliminate these effects we must observe with a space based telescope. However, we use atmospheric models to fit for atmospheric water absorption lines, and remove them.

Cropping, Spatial, and Spectral Alignment

Observing a source with a telescope causes some unwanted effects. One of those effects is a result of our position relative to the source. We do not wish to see the source from our perspective, but rather in a more convenient manner. For example if we take a camera, and snap a picture of a perfect square drawn on the wall, the picture might not show a perfect square. The square might be distorted depending on the position from where the picture was taken. We correct this distorted picture and produce a new more convenient picture which shows the square as a perfect square.

Bad Pixels

Limitations and imperfections of the charge coupled devices used in the VLT results in set of hot, dead, and randomly fluctuating pixels. We remove these outliers by setting a threshold of 10 times the standard deviation .

Preliminary Results

After reducing our data, we fit molecular emission models, and search for protoplanetary disk emission. This process has not yet been completed , but is in progress. As for one of our target stars, "FZ Tau" , we find marked water, hydrogen cyanide, and hydroxide emission lines as seen in Figure 1.

FZ Tau Reductions

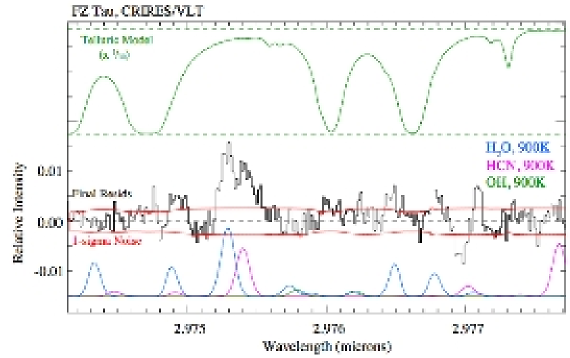

Figure 1.

In Figure 1. we see a model of the the atmosphere in green, molecular models in blue, pink, and green, and reduced data in black. Comparing the Fz Tau reductions to the molecular models we can clearly see water, hydrogen cyanide, and hydroxide emissions present.