# Rotational Spectroscopy and Observational Astronomy of Prebiotic Molecules

Thesis by

Susanna Leigh Widicus Weaver

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# Abstract

It is now widely believed that prebiotic molecules were delivered to the early Earth by planetesimals and their associated interplanetary dust particles. Yet the formation pathways for these molecules are not clear. Amino acids and sugars have been found in carbonaceous chondrites, but only much simpler species have been detected in the interstellar medium (ISM). Prebiotic organics could have formed in the ISM and been directly incorporated into planetesimals, or simpler species could have formed in the ISM and then been incorporated into planetesimals, undergone further processing, and been delivered to Earth. Limits on interstellar chemistry must therefore be established through observational astronomy before potential prebiotic formation pathways can be assessed. These observations require laboratory spectroscopic investigation of the species of interest.

This thesis is an interdisciplinary study involving laboratory rotational spectroscopy and astronomical observations of several key prebiotic molecules. The laboratory work has focused on obtaining the rotational spectra of the simplest three-carbon ketose sugar, 1,3-dihydroxyacetone, and its structural isomers methyl glycolate and dimethyl carbonate, as well as aminoethanol, the predicted interstellar precursor to alanine. The pure rotational spectral analysis of the low-lying torsional states of the simplest $\alpha$-hydroxy aldehyde, glycolaldehyde, has also been completed. The original Balle-Flygare Fourier transform microwave spectrometer was used to obtain the microwave spectra, while both the Jet

Propulsion Laboratory and Caltech direct absorption flow cell spectrometers were used for additional direct absorption millimeter and submillimeter studies.

The results of these laboratory experiments were used to guide observational searches with the Caltech Submillimeter Observatory, the Owens Valley Millimeter Array, and the Green Bank Telescope toward the hot core sources Sgr B2(N-LMH), Orion Hot Core/Compact Ridge, and W51 e1/e2. Evidence has been found for the presence of dihydroxyacetone and methyl glycolate in Sgr B2(N-LMH).

These results have important implications for interstellar grain surface chemistry, and proposed additions to grain surface chemical models are also discussed. Reactions involving surface radicals and molecules containing carbonyl groups can efficiently compete with the simple grain surface reactions included in previous models. Such aldehyde abstraction reactions should be considered as pathways to complex carbonyl-containing species on interstellar grain surfaces.

# Contents

# List of Figures

# List of Tables