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UDC _____ 编号 _____

# 中国科学院紫金山天文台

# 博士后出站报告

## 恒星形成相关分子气体探针观测研究

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学科专业名称 天体物理学

报告提交日期 2017年8月

报告评审日期 2017年8月

# Molecular Gas Tracers and Star-Formation – Observational studies

# 恒星形成相关分子气体探针观测研究

**Postdoctoral Research Report**


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July 2014 – August 2017

I would like to dedicate this report to my loving wife and son.

# Abstract

This report summarize some of the most important work I have been doing during my postdoc program in Purple Mountain Observatory, Chinese Academy of Sciences.

My research interest have been focusing on understanding the relationships between molecular gas and star formation, especially those happen on galaxy scales. This require us to study different tracers of molecular gas, and try to conduct a multi-species, multi-transitions diagnostic of the star formation activity. I will first present the observational study of $C_2H$, which is a representative hydrocarbon and is very abundant in the interstellar space. Its chemical behavior offers important information about the history of star formation. Based on our previous SMA study, we have conducted follow-up observations with CARMA and JCMT, so that we can combine different resolution to explore the properties of $C_2H$ on different scales. The JCMT mapping nicely show the distribution of $C_2H$, which is abundant and diffuse, mostly follow the dust distribution, but the $C_2H$ to dust ratio shows variation among regions.

Then I will present the observations of $HC_3N$, which is supposed to be a optically thin dense gas tracer. Because many dense gas tracers such as HCN and $HCO^+$ are optically thick, the estimation of dense gas mass based on these tracers are biased. Optically thin lines like $HC_3N$ emission, are thus important for the calculation of dense gas mass. This will improve the understanding of the relation between the mass of dense gas and star formation rate (star formation law). Our Effelsberg 100m and SMT 10m observations show low detection rate of $HC_3N$ 2-1 and 24-23, and we discuss the possible reason, and the ratio between $HC_3N$ and HCN.

Finally, I will present the most important project I have been working on, a JCMT large program MALATANG, which aims to get spatial information of two dense gas tracers HCN and $HCO^+$ with HARP array. It is the first systematic survey of resolved HCN and $HCO^+$ in galaxies. We have spent all 390 hours of JCMT observing time since Nov. 2015 till Jul. 2017. All data are obtained, and preliminary data reduction are presented. Detection rate is lower than predicted, and for a significant portion of the sample we only got detection for the central pixel. Nevertheless, We have fully resolved the central $2'$ regions of six galaxies, and the relations between HCN and $HCO^+$ line luminosities and infrared luminosity are analyzed.

The ratio between the two lines and its variation among different galaxies/regions is also discussed. Other scientific questions, including the dense gas ratio (HCN and/or $HCO^+$ to CO ratios), will be also analyzed in the near future.

这份博士后工作报告总结了我在紫金山天文台进行博士后工作期间进行的一些主要科学观测项目。

我的研究兴趣集中于对分子气体与恒星形成的关系进行观测研究，尤其是在星系尺度上。这要求我们对不同的分子气体探针的性质进行细致的分析和理解，并利用多分子、多跃迁的谱线诊断工具去对恒星形成过程得到进一步的认识。我会首先展示我们对$C_2H$ 分子进行的观测工作。这是一个典型的碳氢化合物，在星际空间非常丰富，并且与恒星形成的演化阶段很可能有密切相关。基于之前的SMA 观测研究基础，我们利用CARMA 和JCMT 望远镜开展了后续研究工作，意图结合不同的分辨率对该分子在不同尺度上的性质进行详细分析。JCMT 成图较好地展示了$C_2H$ 的弥散的空间分布，其与尘埃的分布大致相同。但$C_2H$ 与尘埃的比值在不同的样本中呈现出一定的差别，可能表明了不同源所处演化阶段不同。

其次是展示对致密分子气体探针$HC_3N$ 的观测研究。由于多数常用的致密分子气体探针，如HCN，$HCO^+$ 等多为光厚谱线，使得计算致密分子气体质量时会有一定的偏差。而像$HC_3N$ 一样的光薄谱线，可以提供更准确的致密分子气体质量测算。我们使用Effelsberg 100米和SMT 10米望远镜分布对$HC_3N$ 2-1 和24-23 的发射线进行了观测。受天气设备影响，探测率较低。我们对$HC_3N$ 和HCN 在不同星系中的比值进行了讨论。

最后将介绍我正在参与的JCMT 大项目MALATANG，对HCN 4-3 和$HCO^+$ 4-3 进行系统巡测的工作。我们使用JCMT 的HARP 接收机对22 个星系进行了390小时的观测。所有数据已经采集并进行了初步的处理。初步结果显示这两条谱线的发射强度要低于预计，所以总体的探测率不高。我们对6个星系进行的2′ 范围的全覆盖观测，提供了丰富的星系中心区域的HCN 4-3 和$HCO^+$ 4-3 发射信息。我们对发射线光度与红外辐射光度之间的关系，以及两条谱线的比值在不同区域的变化进行了讨论。其他的相关分析工作也正在进行之中。

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