

平成(29)年度国立天文台滞在型共同研究報告書
Activity Report for NAOJ Visiting Joint Research in FY (2017)

2018年05月31日
YYYY/MM/DD

申請者 Applicant	氏名 Name	Satoru Iguchi
	所属・職 Division・position	NAOJ Chile Observatory・Professor
研究課題名 Research Title	<i>Black Hole Mass Measurements Using Molecular Gas Kinematics in starbursting galaxy NGC 253</i>	
研究場所 Place	Mitaka	
共同研究者 氏名・所属・職名 Joint researcher's Name ・Institution・Position/ Graduate Student year	Dieu D. Nguyen Department of Physics and Astronomy – The University of Utah – Research Assistant	
1. 研究概要 (Summary of research)		
<p>The project we want to conduct at the NAOJ during the visiting is that “Black Hole Mass Measurements Using Molecular Gas Kinematics in starbursting galaxy NGC 253”. In this project, we are going to use the archival ALMA $^{12}\text{CO}(2-1)$ observation of the nucleus of the starburst galaxy NGC 253 at the angular resolution of $0''.07$ (PI: Kouichiro Nakanishi). To dynamically measure the mass of this black hole, we employ the KINematics Molecular Simulation (KinMS) model to simulate the observations of the cold $^{12}\text{CO}(2-1)$ molecular distributions in the circumnuclear disk (CND) and measure the gas kinematics within a few tenths of an arc-second. The KinMS modeling requires the inputs of ALMA observation of $^{12}\text{CO}(2-1)$ and the mass model of the galaxy. The mass model represents the whole galaxy's gravitational force, which governs the motion of the gas and stars components. The presence of a black hole will enhance the increasing of the center gas kinematics within the black hole's sphere of influence. I am going to perform this work under the supervision/collaboration of/with Professor: Satoru Iguchi, my advisor: Professor Anil Seth, and my collaborator: Dr. Timothy Davis.</p> <p>Our plan is going to finish this work and have a complete its manuscript during the visiting. Currently, I am having some of the work including modeling the one- and two-dimensional surface brightness profiles of NGC 253; the most important ingredient to build up the mass model.</p> <p>We hope this work would be published in a refereed journal, e.g., ApJ or MNRAS.</p>		

2. 研究成果(Research achievements)

The analysis of the archival ALMA data (PI: Kouichiro Nakanishi) revealed that the starbursting galaxy NGC 253 is more complicated than our initial expectation because its circumnuclear gas disk (CND) is heavily contaminated by many nucleus star formation regions. The star-forming regions cause an asymmetric CND's position-velocity diagram (PVD) and require tremendous efforts to correct for the PVD by removing these star-forming clumps before doing the KinMS model for the CND's kinematics and central black hole mass measurement.

We have come up with two methods to correct the PVD but only tested one of normalization of the spatial $^{12}\text{CO}(2-1)$ emission flux within the CND. This method has improved the PVD but cannot remove some small signatures of asymmetry completely. Future work will test for the second hypothesis of removing the $^{12}\text{CO}(2-1)$ emission from the star-forming clumps based on another isotope of $^{13}\text{CO}(2-1)$ emission, which come from these star-forming regions only. By assuming a hypothesis of a constant line ratio $^{12}\text{CO}(2-1)/^{13}\text{CO}(2-1)$ for star-forming, we will estimate the fraction of $^{12}\text{CO}(2-1)$ emission distributed by star-forming clumps within the CND and subtract it off. The flux fraction left behind is distributed by the $^{12}\text{CO}(2-1)$ emission from the CND only.

We going to get back to this work in this Fall when I return NAOJ for my postdoctoral work there. Due to the above difficulties, it is a better idea that we should take one step down in our claim of measuring the mass of the central supermassive black hole (SMBH) in NGC 253. We only detect and measure an upper limit mass of this SMBH based on the current released archival data. We hope to write up and submit a refereed paper of this work in 2019. Following up observations, analysis, and method developments (e.g., maybe develop a new package adding to the current KinMS model to dealing with such an axis-asymmetric PVD!?) will provide a better constraint on this SMBH mass in such a messy galaxy like NGC 253.

3. 本制度に対する意見、要望など【申請者記載欄】

(Any comments on this program【For applicant】)

The program was so great!

One comment that the institution should have an *eduroam* wifi port so that we can connect to our home university/institution from NAOJ on our private laptop. I wasn't able to use any software that is necessary to the research program during the time I was in NAOJ.

4. 本制度に対する意見、要望など【本事業で来訪した共同研究者記載欄】

(Any comments on this program【For joint researcher】)

5. 共同研究者の滞在日程(Joint research period)

氏名・所属 (Name・Institution)	Dieu D. Nguyen – The University of Utah	
滞在日程 (Period of stay)		日数(days)
年 月 日 2017/12/15	～ ～	年 月 日 2018/02/15
		60 日間(days)
年 月 日 YYYY/MM/DD	～ ～	年 月 日 YYYY/MM/DD
		日間(days)
合 計 (Total)		日間(days)