Title	The Influence of Gravitationally Unstable Protoplanetary Disks on Type I Migration [an abstract of dissertation and a summary of dissertation review]
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Citation	北海道大学. 博士(理学) 甲第14194号
Issue Date	2020-09-25
Doc URL	http://hdl.handle.net/2115/79527
Rights(URL)	https://creativecommons.org/licenses/by/4.0/
Type	theses (doctoral - abstract and summary of review)
Additional Information	There are other files related to this item in HUSCAP. Check the above URL.
File Information	Nguyen_Kim_Ngan_review.pdf (審査の要旨)

Doctoral Dissertation Evaluation Review

Degree requested Doctor of Science Applicant’s name Ngan Kim Nguyen

Examiner :
Chief examiner Visiting Associate Professor Elizabeth J. Tasker
Associate examiner Professor Kiyoshi Kuramoto
Associate examiner Professor Tatsuo Kobayashi
Associate examiner Lecturer Takashi Okamoto

Title of Doctoral Dissertation

The Influence of Gravitationally Unstable Protoplanetary Disks on Type I Migration
(重力不安定原始惑星系円盤の I 型惑星移動への影響)

Results of Evaluation of the Doctoral Dissertation (Report)

Two main methods of planet formation have dominated the field. The first is ‘core accretion’ whereby planets form through the steady accumulation of solid material. The second is ‘gravitational instability’, whereby planets form similar to stars in a fragmenting protoplanetary disc. The latter method is now not considered to be likely inside about 40 au from the star and interest in this method largely disappeared. However, new observations from ALMA show that protoplanetary discs are rich in structure, such as spiral arms. While these structures may not result in gravitational collapse into a planet, it seems likely that they still affect planet evolution. The author therefore ran simulations to study the impact of a borderline gravitational protoplanetary – similar to those observed by ALMA—on the orbit of a young planet embedded in the gas.

In this study, the author used the hydrodynamics code, ChaNGA, to simulate the gas disc and the planet. Gas drag on the planet resulted in an exchange in angular momentum between the planet and disc known as ‘Type I migration’. The author followed the resulting migration for two different planet masses (10 Earth masses and 33 Earth masses) in multiple different disc environments. The results shows that the torque on the planet is affected by disc instability, resulting in an often strong deviation from the migration rate predicted from analytical estimations.

The author also presented results for the formation of star-forming clouds in a galactic disc. This was the culmination of work began during the author’s MA, that was then completed and publishing in the first year of her doctoral course. This work demonstrated that the background gravitational potential of a galaxy can impact the number of small and large star-forming clouds, although a typical cloud has common properties regardless of the galactic potential.

In conclusion, the author proved that the protoplanetary disc structure cannot be ignored when considering planet migration rates, and may increase the speed or even reverse the direction of a planet’s orbital change. This is an important result for understanding the architecture of planetary systems. Therefore, we acknowledge that the author is qualified to be granted a Doctorate of Science from Hokkaido University.