Time variation of the correlation of the flux variations between 6.7GHz methanol maser spectral components in the massive star forming regions

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Background & Purpose

6.7GHz methanol maser is one of the tracers for massive star forming region. Yet, the condition of the maser excitation and the origin of flux variation have not been understood. To investigate the formation process of massive stars with this maser, it is necessary to understand the properties of 6.7GHz methanol maser. In this study, we analyzed the spectra of 6.7GHz methanol maser for 16 sources that have been monitored for a long time at Ibaraki station. Based on the correlation of flux fluctuations in these sources, we discuss the excitation and variability model of 6.7GHz methanol maser.

How to choose

We have selected 16 sources from 452 sources of 6.7GHz methanol maser that meet two conditions as follows.

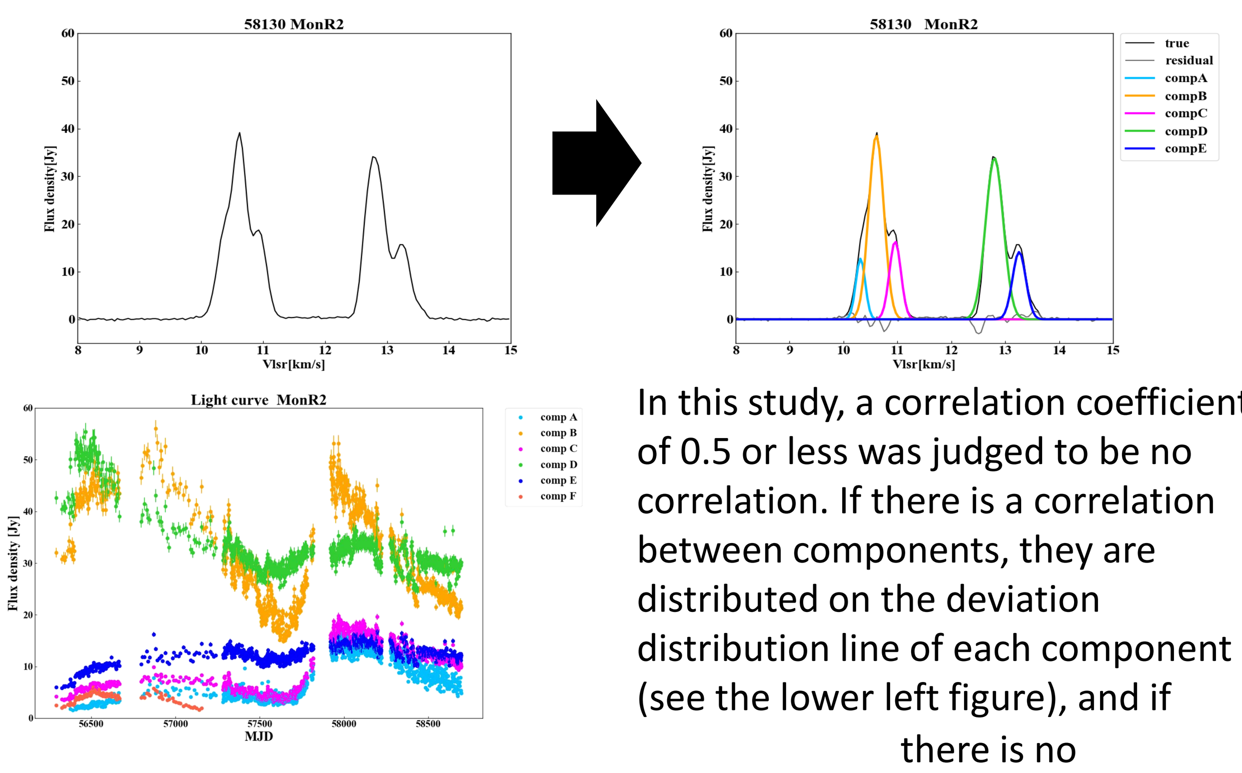
(1) Long-term observations (over 250 days) from 2013 to 2019.

(2) There are 3 or more peaks with SNR of 80 or more.

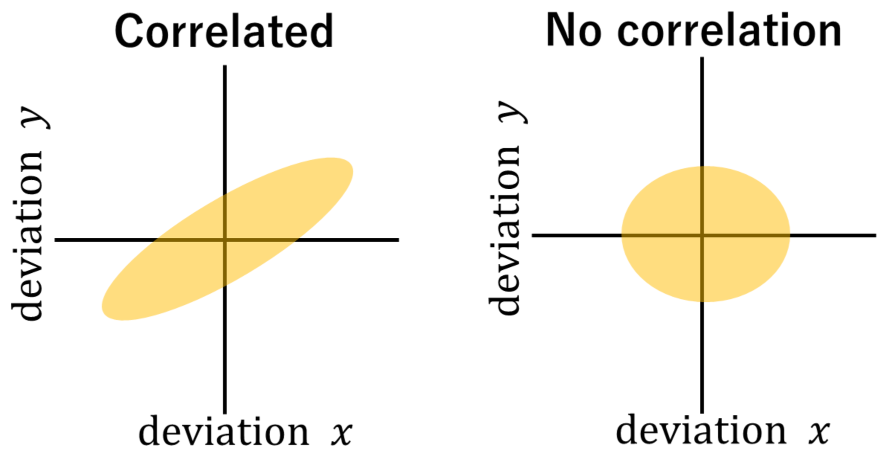
Out of 16 sources, the results of 9 sources are presented. The rest 5 sources have spectra of seriously overlapping components or disappeared during the observing period.

Analytical method

In order to identify each component, the Gaussian function was fitted to the peak on the spectrum using the method of least squares. We create a light curve and a dispersion chart, from the identification of maser components. Then we calculate the correlation coefficient.



In this study, a correlation coefficient of 0.5 or less was judged to be no correlation. If there is a correlation between components, they are distributed on the deviation distribution line of each component (see the lower left figure), and if there is no correlation, they are distributed in a circle around the center (see the lower right figure).



Spectra and Light curve

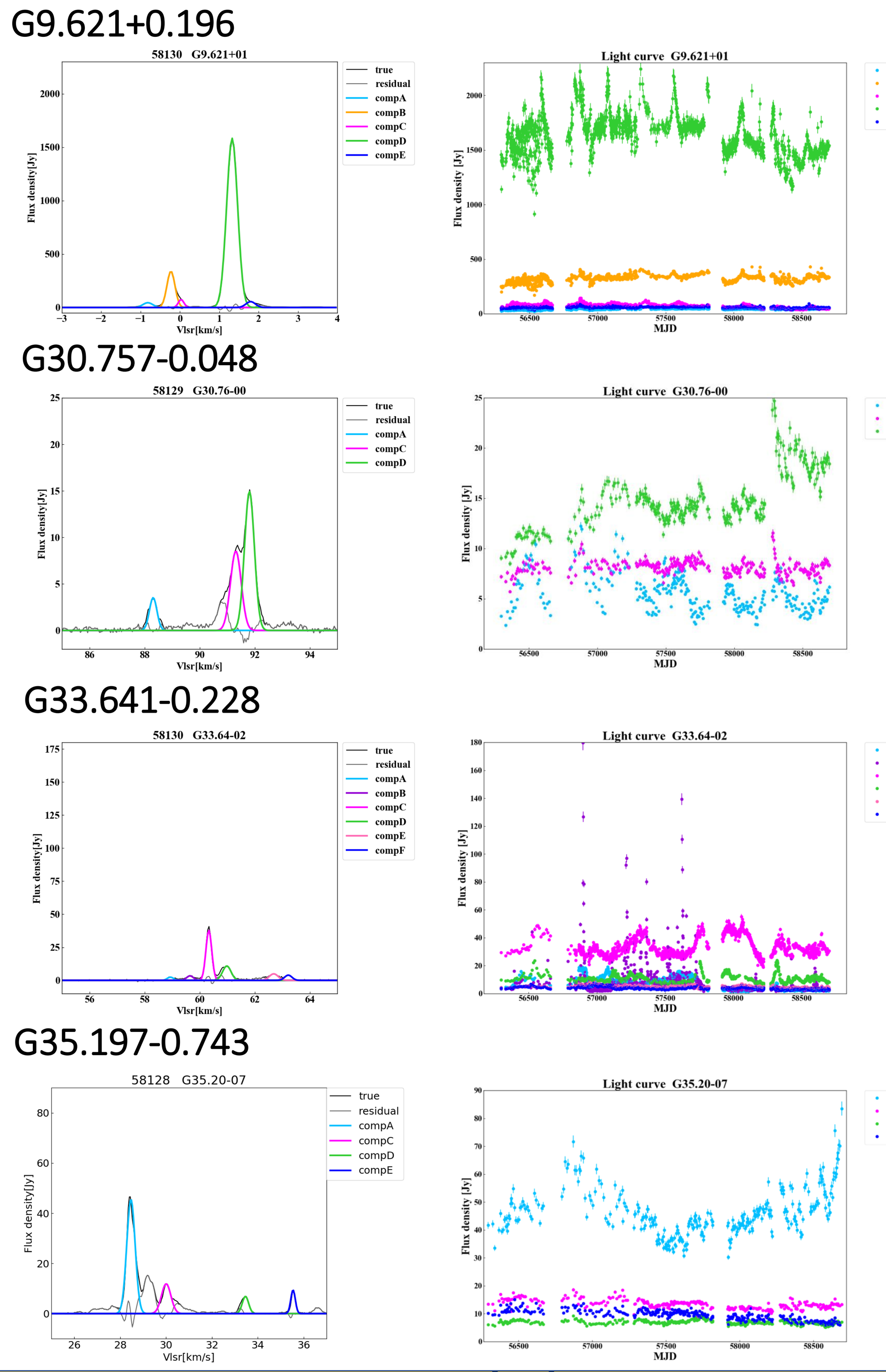
＊Details of MonR2 and W75N are below

G9.621+0.196

G30.757-0.048

G33.641-0.228

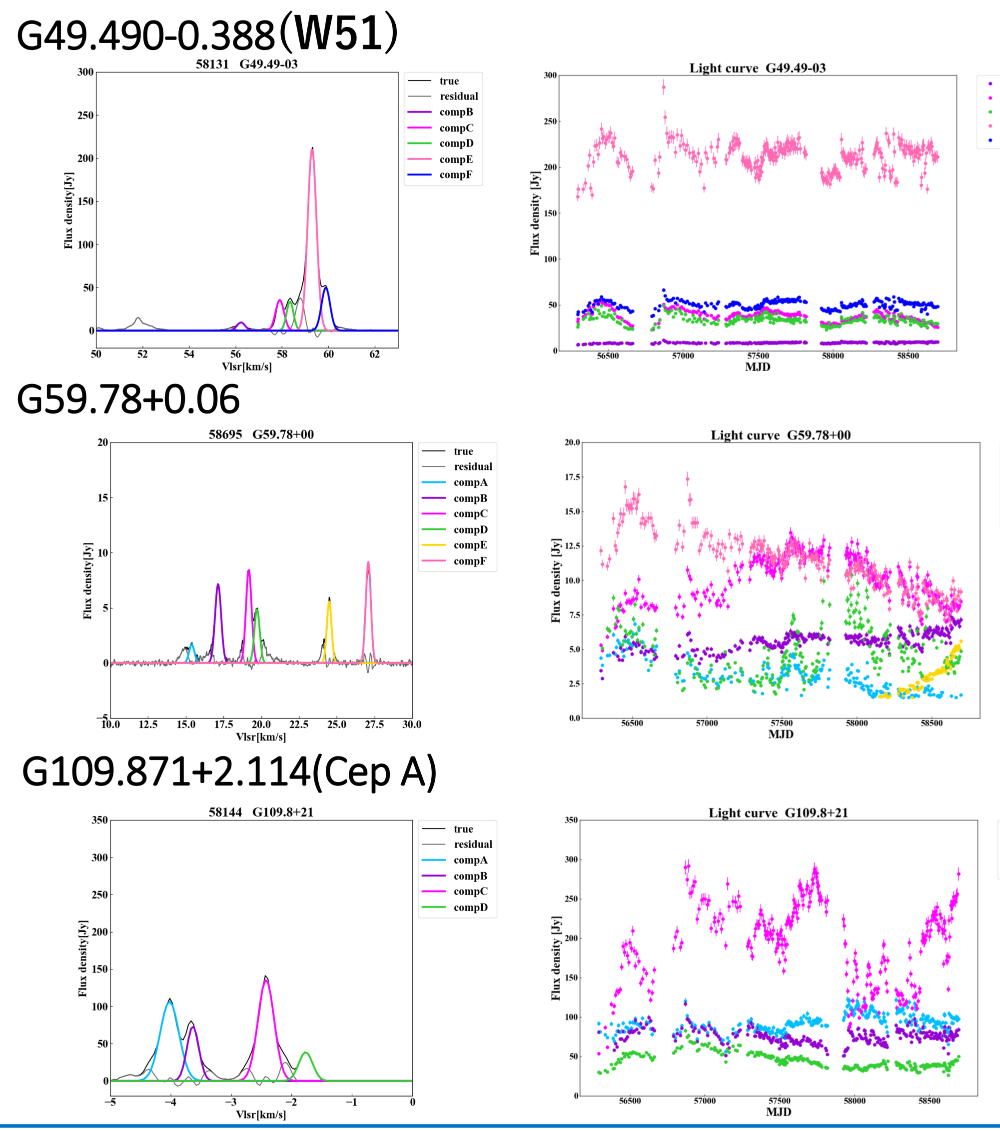
G35.197-0.743



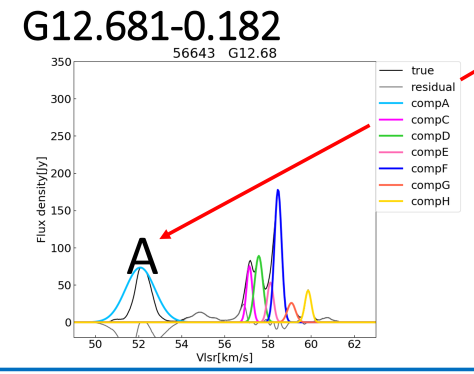
G49.490-0.388(W51)

G59.78+0.06

G109.871+2.114(Cep A)



G12.681-0.182



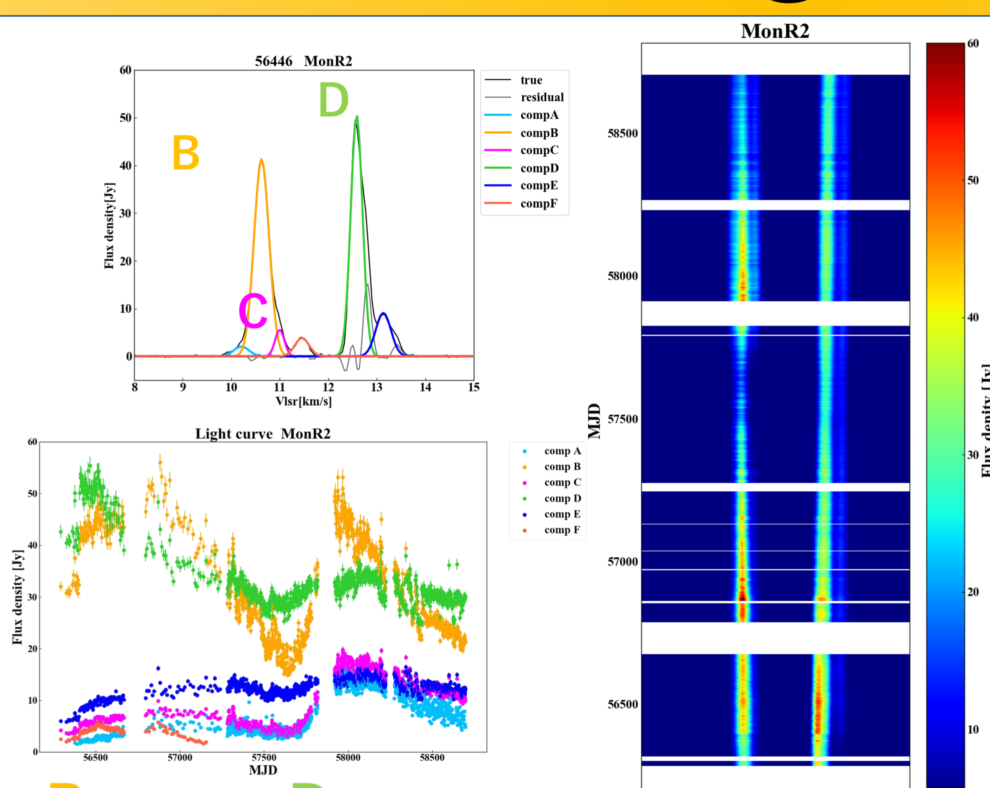
Multiple components overlap and cannot be decomposed.(like component A)
Regarding the source that could be analyzed, the data that could not be fitted was judged visually, and there was no data from the light curve and correlation calculation.

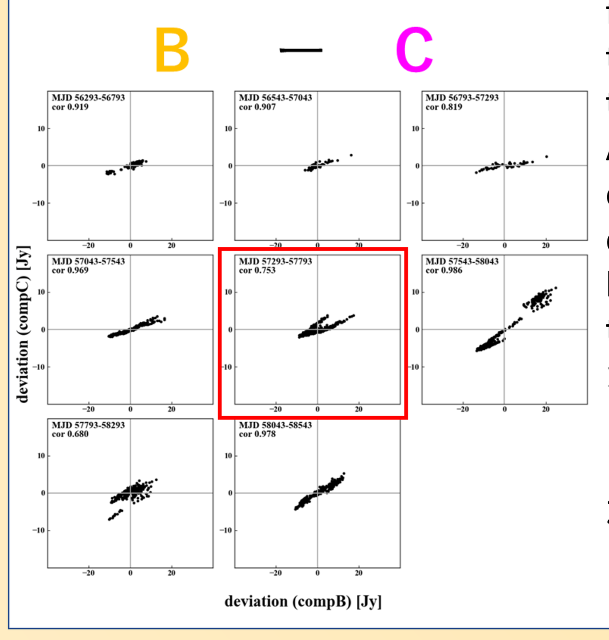
G213.71-12.60 (Monoceros R2)

This maser observed from this source is considered to have periodic intensity fluctuations.

We here focus on component of B, C and D. In the past research of MonR2 at Yamaguchi University, the spectral components with three distinct velocities have reported to have a period of about 20 days, so they thought the three components have the same excitation source.

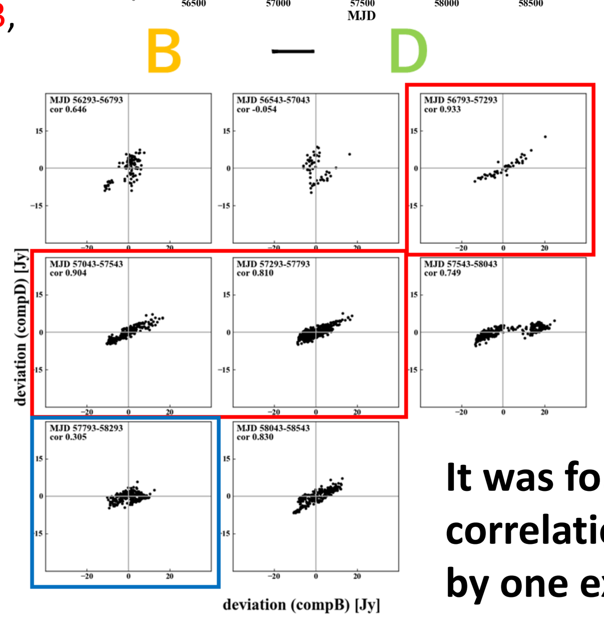
In this study, in order to discuss the change in the correlation, the variance of the correlation coefficient and the intensity change was calculated by shifting the time by 250 days in the period of 500 days.





Two correlation trends are found. In MJD57293-57793, the 2nd correlation trend(steeper) appears. After that, the 1st correlation trend disappears. The difference between before and after the change is as follows.

1. Maser spot environment has changed
2. Has the same velocity but radiates from different spots



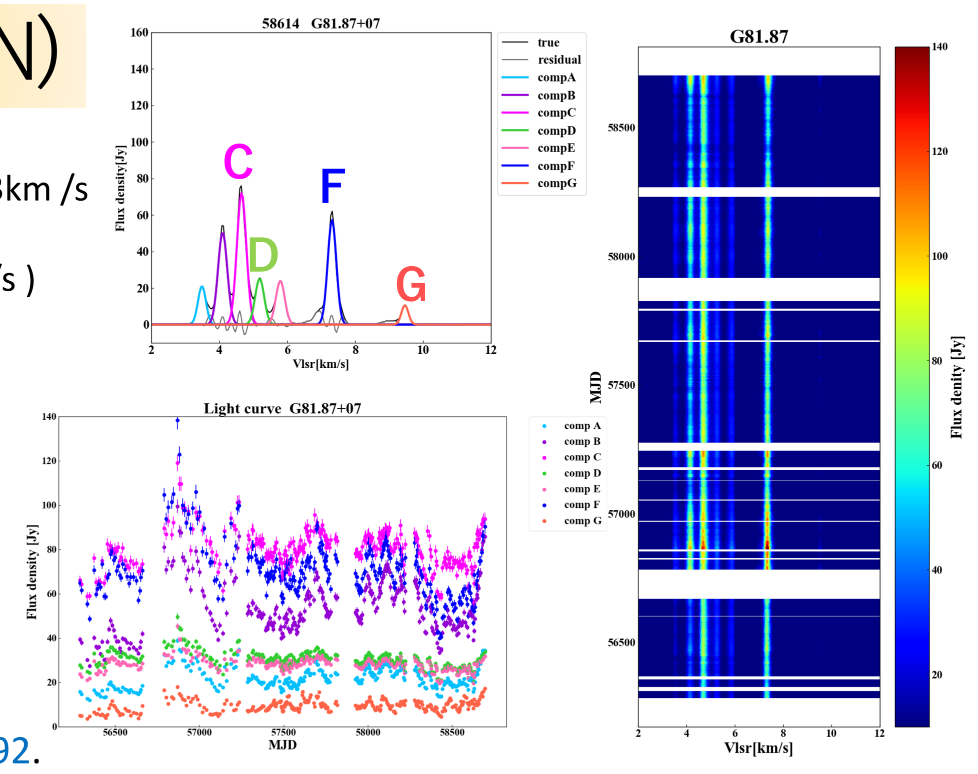
MJD56793-57793: A strong correlation (>0.8) is seen. MJD57793-58293: No significant correlation (0.3).

This result shows that the excitation source of the maser differs depending on the time.

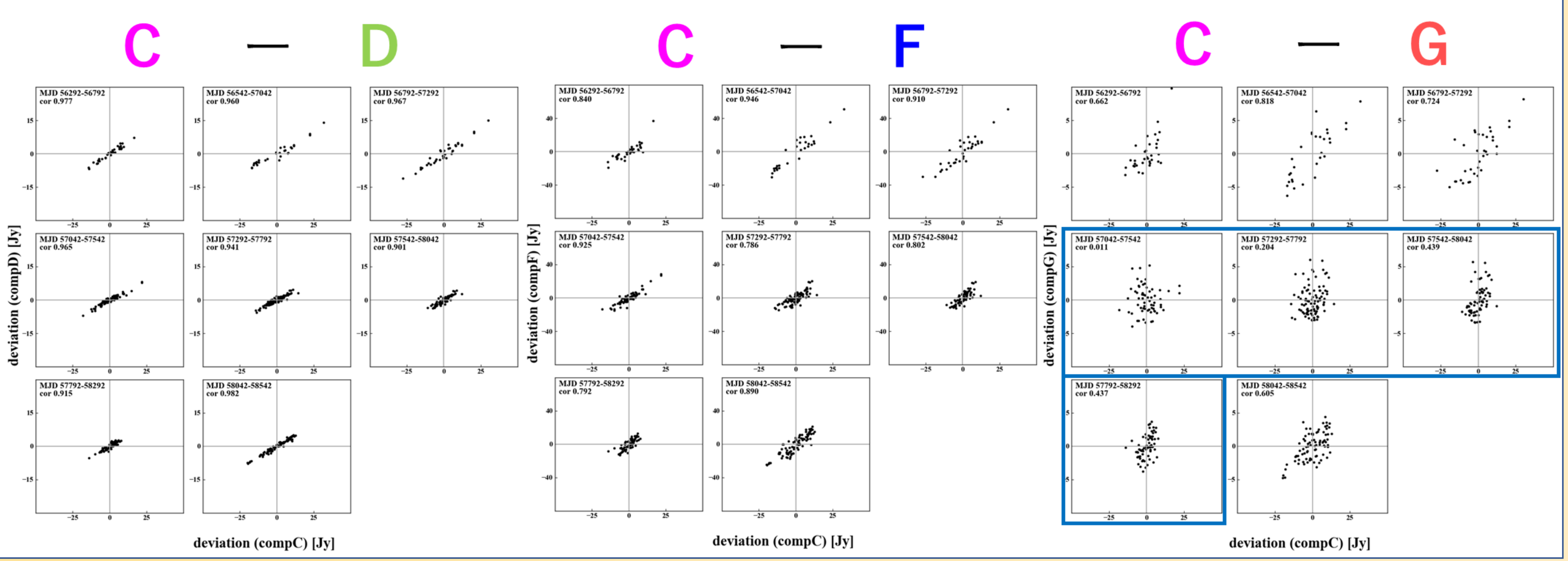
It was found that the change in correlation might not be explained by one excitation source

G81.87+0.78(W75N)

We here focus on component C,D,F,G.
There are some peaks from velocity of 3km /s to 6km/s and two peaks in a little away. (7.278 ± 0.016km/s & 9.434 ± 0.006km/s)

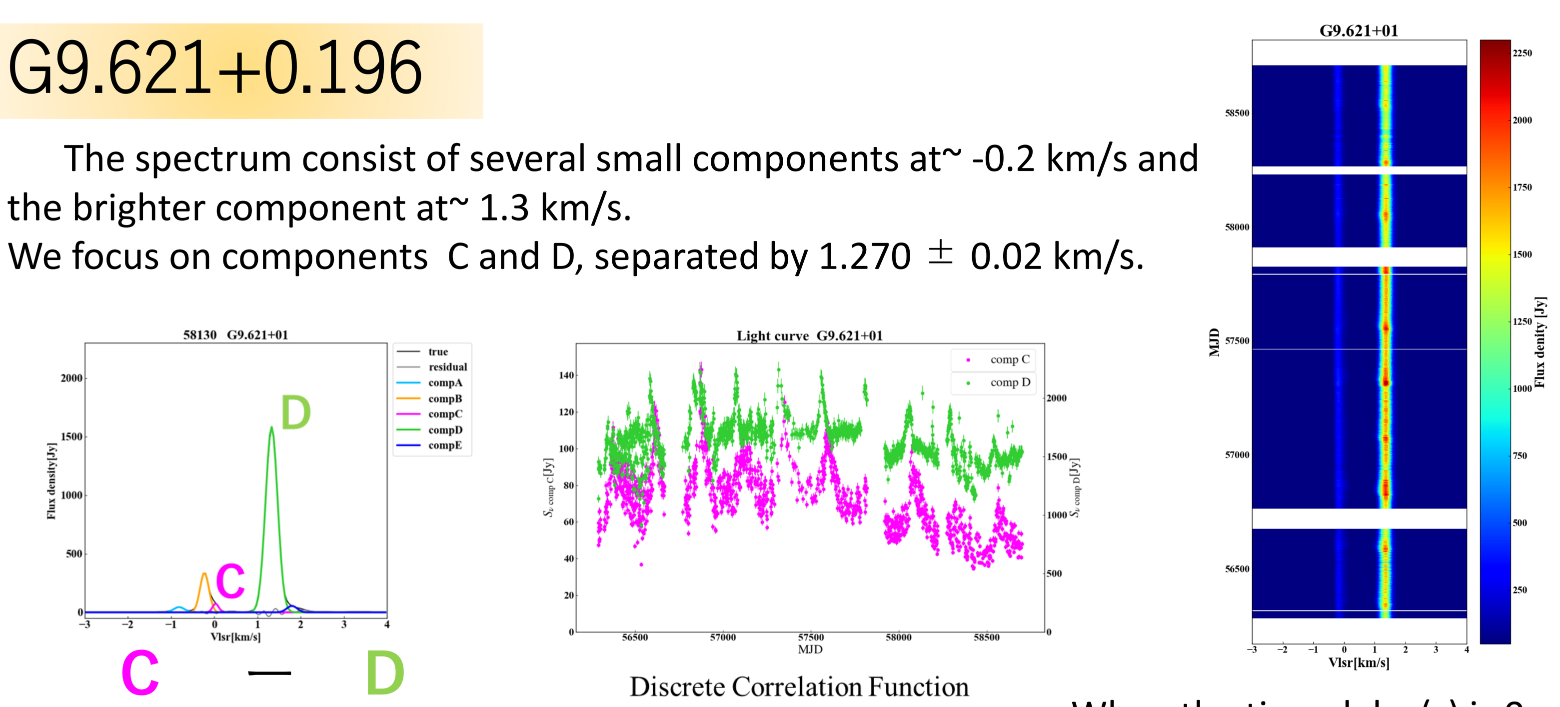


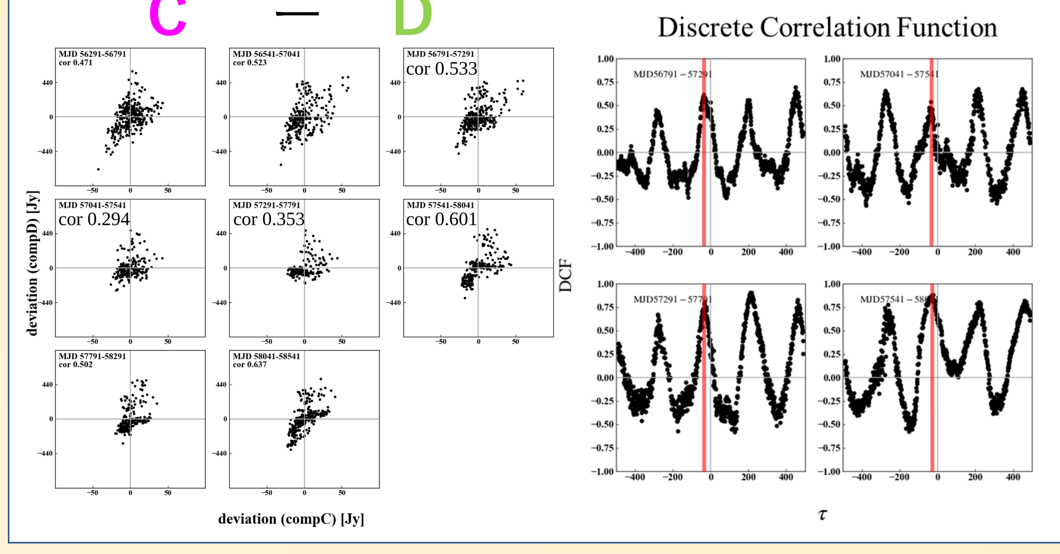
C-D and C-F show continuous good correlations (>0.5).But C-G does not show significant correlation (<0.5) during MJD57042-58292(<0.5).
From the fact that the velocity of G is far from other maser components, G is considered that influenced by an excitation a source different from other components in MJD57042-58292.



G9.621+0.196

The spectrum consist of several small components at~ -0.2 km/s and the brighter component at~ 1.3 km/s.
We focus on components C and D, separated by 1.270 ± 0.02 km/s.





When the time delay(τ) is 0, no significant correlation. But when the correlation function was calculated, there was a correlation with >0.5 at τ=-27days.It implies that the distance of C from B is 5000AU(27days × light speed). Than these excitation sources are considered to be the same.

Future work

We consider the relationship between spatial distance and correlation by combining monitoring observation with a single-dish and observation of spatial distribution by VLBI. Make sure that the highly correlated component pairs are spatially close.

Discusses the model of properties and excitation mechanism of 6.7GHz methanol maser

Summary

・16 sources were selected from the 6.7 GHz methanol maser sources monitored at Ibaraki University, and the spectra were separated to calculate the correlation coefficients and correlation functions of each flux density over time.

・From the correlation coefficient and variance of the deviation, it was found that there is a source whose correlation between components changes with time(MonR2, W75N) .

MonR2 B-D　　Correlation (>0.5)→No correlation(<0.5)

MonR2 B-C　　The slope of the variance changes

・ By the correlation change, it is difficult to assume that all components on the spectra observed by each source have intensity fluctuations due to a single excitation source.

・ It is necessary to combine VLBI observations with single-dish observations to see if there is a correlation between correlation changes and spatial changes.