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著者(和文)	李尚姬
Author(English)	Sanghee Lee
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We investigated the magnetic activity variability for F-, G- and K-type stars (τ Boo, υ And, β Vir, α CMi, β Com, κ^1 Cet, π^1 UMa, β Aql, 61 Vir, ε Eri, η Cep, HD 102195) by monitoring HIDES-F Hα line over the last four years, in terms of activity cycles, amplitudes of variability, and exoplanet searches. We described HIDES-F Hα observations, the echelle data reduction, and analyses to evaluate the Hα variability for each target star. As a result, the target stars have shown their intrinsic magnetic activity variability, respectively.

We presented the possible dependence of the Hα variability on stellar parameters, especially on the activity level of the target stars. Between the Hα variability and stellar age or Rossby number, there might be a weak correlation which indicates that stars with the similar age or Rossby number could show different activity variability. Although it is not easy to present a clear dependence of the activity variability on stellar age and Rossby number in this Hα observation, it implies that the difference of activity variability is caused by a complex of stellar parameters and needs to be established through more cases. As the Hα variability is in a good agreement with log R'_{HK}, the activity level calculated from the Ca II H&K line, we suggest that the Hα variability can be properly used as an activity indicator. Our Hα flux time series covered a new observing period, and its flux is strong enough to trace the activity variability of the F-, G- and K-type stars.

We suggested that the magnetic activity variability represents different behaviors of the activity cycle depending on stellar spectral type. For the F-type target stars (τ Boo, υ And, β Vir, α CMi), the existence of a possible activity variation has been presented. The clear cycle of 123-day for τ Boo has been detected, and it is precisely consistent with the previous Ca II H&K results. Also, the possibility of a short cycle within 1-2 years for β Vir and α CMi have been suggested by the Hα variability. For α CMi, the possibility of temporal absence of its short cycle is speculated. We also suggested the range of amplitudes for the Hα variability that could be detected as the short-term period for each star. Though a clear activity cycle period for υ And was not detected in this observation, our Hα results could be supportive examples for the short-term activity cycle trend in F-type stars. The short time-frame of the activity cycle in F-type stars would provide a better constraint to future dynamo studies for the Sun-like stars.

For the G-type (β Com, κ^1 Cet, π^1 UMa, β Aql, 61 Vir) and the K-type target stars (ε Eri, η Cep, HD 102195), they also presented the existence of the activity variation. The clear cycle of 2.9-year for ε Eri has been detected, and it is precisely consistent with its shorter cycle of co-existing cycles reported by the previous Ca II H&K results. The Hα results of ε Eri could support the idea that the Sun-like stars have two different cycles simultaneously. It also supports the suggestion of the two different dynamos operation. For some G-type stars, we suggested their long-term activity variation possibly associated with their longer cycle of co-existing cycles. The expected shorter cycle period was not detected in this observation, nevertheless, we set an upper limit of non-detection for the short-term period component of activity cycles for β Com and κ^1 Cet. The Hα results of β Com and κ^1 Cet are able to provide supportive information of amplitudes range of activity variability for shorter cycles, to subsequent observations. For the rest of the G- and K-type stars, we suggested an upper limit of non-detection for a periodic variation, which also could be supportive conditions for following observations.

Additionally, we investigated the activity variations between the Hα and the Hβ line. Although we could not find an identical correlation of long-term variations for the target stars, we suggested observational evidence of the different relationship of each star. It is speculated that there might be a relatively strong correlation for the stars which showed a long-term variation dominantly. It could be helpful for future studies of relationships between the chromospheric lines.

With respect to the SPMI detection, for target stars with a hot-Jupiter, τ Boo, υ And, and HD 102195, any periods possibly induced by their hot-Jupiter have not been detected. We set an upper limit of non-detection of the SPMI. It is suggested that the magnetic activity variability detected in this Hα observation is related to the stellar intrinsic activity rather than the existence of exoplanets. This also could support that the short-term activity cycles in the F-type stars are induced by the stellar intrinsic dynamo.

We also investigated the magnetic activity variability depending on stellar spectral type and features of individual stars with a focus on exoplanet searches. It is suggested that the magnetic activity variability could affect the RV differently by spectral type. It would be supportive information for target selection of exoplanet searches. We also speculated that the magnetic activity variability with the detected amplitude in the Hα observation is not correlated with the RV variations for most individual target stars, though there is still the possibility that the magnetic activity variability may induce RV variations for few stars. In addition, we suggested the range of the amplitudes of the Hα variability that may or may not induce a stellar noise to the RV. It could provide useful conditions to future exoplanet detection for the individual stars.

We presented the efficiency of the Hα line with the difference of the variability amplitudes between the Hα and the Ca II H&K line observationally. Though the Hα variability tends to show smaller amplitudes, it would provide a strength in exploring activity variability in finer range of amplitudes. Our Hα variability is expected to estimate adequately the amplitude range of activity variability that could affect future exoplanet and activity cycles searches for other stars.

For the relationships between the stellar activity cycles and the rotational periods, our Hα observations help to understand the scatters and possible tendency of the branches. With intensive and high cadence monitoring, we supported the existence of extremely short periods of F-type stars in the inactive branch and the possibility of a sub-sequence in the active branch, which might have been the reason of the scatters in the current diagram of the relationships. Additionally, we suggested that a distinct short-term activity variation could be more dominant than a long-term variation, using the Hα results of the F-, G- and K-type stars together. The dominance or temporal absence of the short cycle suggested by our observations could explain few cases of the stars with detected co-existing cycles. Although our results of some G- and K-type target stars support the suggested conditions of co-existing cycles, further observations might allow us to establish the possible condition as we speculated it could be more complicated. It would also be helpful to select targets possibly have co-existing cycles and lead to better understanding of the relationships between the stellar activity cycles and the rotational periods.