OKAYAMA PLANET SEARCH PROGRAM: SEARCH FOR PLANETS AROUND G-TYPE GIANTS. B. Sato, *Okayama Astrophysical Observatory, National Astronomical Observatory of Japan, Honjyo, Kamogata, Asakuchi, Okayama 719-0232, Japan, (satobn@oao.nao.ac.jp)*, E. Toyota, Y. Itoh, *Graduate School of Science and Technology, Kobe University, 1-1 Rokkodai, Nada, Kobe 657-8501, Japan*, H. Izumiura, S. Masuda, M. Yoshida, *Okayama Astrophysical Observatory, National Astronomical Observatory of Japan, Honjyo, Kamogata, Asakuchi, Okayama 719-0232, Japan*, Y. Takeda, H. Ando, E. Kokubo, *National Astronomical Observatory, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan*, E. Kambe, *Department of Earth and Ocean Sciences, National Defense Academy, Yokosuka, Kanagawa 239-8686, Japan*, S. Ida, *Tokyo Institute of Technology, Ookayama, Meguro-ku, Tokyo 152-8551, Japan*.

More than 150 extrasolar planets have been found over the last 10 years from precise Doppler surveys. While most of them are identified as companions to solar-like stars, those discovered in more evolved stars, such as G, K giants, are currently increasing in number. Generally speaking, it is difficult to detect planets around cool giants because their intrinsic radial velocity variability reaches up to several hundreds m s^{-1}, which is much larger than expected from orbiting planets of several tens m s^{-1} at most. Recent observations, however, have revealed that many late G- and early K-type giants are stable in radial velocity to a level of $\sigma < 20$ m s^{-1} [1][2]. It will allow us to detect giant planets in orbits relatively close to central stars and thus make these types of stars promising targets in Doppler planet searches.

Searching for planets around G, K giants is important in the point that they cover a range of stellar masses of $> 2\ M_{\odot}$ which has been mostly ignored in Doppler surveys so far. Such massive stars have lifetimes much shorter than those of lower mass stars and may have shorter-lived surrounding disks (<a few Myr; [3]), which means that time allowed for planet formation is also much shorter. Therefore, the existence of planets around such stars would constrain the time scale of planet formation and verify the current planet formation theory. Little is known, however, about planetary systems in massive stars because precise radial velocity measurements are difficult when such stars are on the main-sequence (early-type stars) due to the lack of appropriate absorption lines in their spectra. On the other hand, late G and early K giants, massive stars on evolved stages, have many sharp absorption lines appropriate for precise radial velocity measurements while the stars themselves remain relatively stable against pulsation and surface activity.

On these grounds, we are now carrying out a precise Doppler survey of late G (including early K) giants to search for planetary systems around intermediate-mass stars (1.5–5 $M_{\odot}$) using HIgh Dispersion Echelle Spectrograph (HIDES) at Okayama Astrophysical Observatory (OAO) in Japan. For wavelength calibration in radial velocity measurements, we use an iodine absorption cell and have maintained a Doppler precision of ~ 6 m s^{-1} over a period of 4 years[4][5]. Our survey targets are selected from the Hipparcos catalogue according to the following criteria: stars with 1) $V < 6$ to attain a sufficient signal-to-noise ratio, 2) a color index of $0.6 \leq B-V \leq 1.0$ to achieve intrinsic radial-velocity stability to a level of $\sigma \leq 20$ m s^{-1}, 3) an absolute magnitude of $-3 \leq M_V \leq 2$ to include stars with masses of 1.5–5$M_{\odot}$, and 4) a declination of $\delta > -25^{\circ}$ to be observed from OAO.

The program began with about 60 stars in 2001 July and since 2004, it has enlarged to include 300 stars in total. Up to now, we succeeded in discovering the first extrasolar planet around a G-type giant star HD 104985 ($P = 198.3$ d, $K_1 = 163$ m s^{-1}, $e = 0.06$; [6]) and found several new spectroscopic binaries. We also found that most of the targets have radial velocity scatters of $\sigma \sim 10$ m s^{-1}, with the most stable reaching levels of 6–8 m s^{-1}[2]. It confirms that G-type giants are suitable for Doppler planet searches. To clarify the properties of our targets, such as the atmospheric parameters, mass, and evolutionary status, we investigated the chemical abundances of various elements for all of our targets. The first results of abundance analyses of about 60 stars are presented in [7]. Recently, we identified several new stars showing periodic radial velocity variations with periods of $200 \sim 1000$ d and amplitudes of $50 \sim 100$ m s^{-1}, suggesting the existence of substellar companions with masses of $2 \sim 10\ M_J$ adopting stellar masses of about 2 $M_{\odot}$. Their eccentricities seem to be relatively low, $e = 0 \sim 0.3$. These discoveries suggest that planets can be formed around early-type main-sequence stars with masses of $\sim$2 $M_{\odot}$ as well as around lower-mass stars and that they have a diversity in their properties. Since 2005, we have added new 300 G, K giants ($V > 6$) to our targets which are now being surveyed in collaboration between Korean and Chinese groups using 1.8m telescope in Korea and 2.2m telescope in China. We here report the current status of our project and discuss future prospects.

REFERENCES

[1]Frink et al. 2001, PASP, 113, 173
[2]Sato et al. 2005, PASJ, 57, 97
[3]Haisch et al. 2001, ApJ, 553, L153
[4]Sato et al. 2002, PASJ, 54, 873
[5]Kambe et al. 2002, PASJ, 54, 865
[6]Sato et al. 2003, ApJ, 597, L157
[7]Takeda et al. 2005, PASJ, 57, 109