２１世紀ＣＯＥ拠点リーダー　鈴木　厚人　殿

# 平成１６年度ＣＯＥ特別研究奨励費研究計画調書

| (ふりがな) 氏　名 | さてゃぶらた　らじ<br>Satyabrata Raj | 所　属 | 資　格 |
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| | | 物理学専攻 | ＣＯＥフェロー（circled）・博士（4年・3年・2年・1年） |
| 研究課題 | ４０文字以内で記入すること。<br>重い電子系超伝導体 $Ce_mTIn_{(3m+2)}$ (T = Co, Rh, Ir, m=1,2)の極低温高分解能角度分解光電子分光 | | |

| 研究指導者 | 職　名 | 氏　名 | 15 年度奨励費採択の有無 |
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| | 教授 | 高橋　隆 | 有・無（circled） |

| 研究目的 | 募集要領の趣旨に沿った目的を箇条書きで具体的に記入すること。 |
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Heavy-fermion systems are intermetallic compounds that exhibit very unusual low temperature properties with low temperature density of electronic states (a narrow f electron band) at the Fermi level. Despite their common description of having a large value for the electronic effective mass, heavy-fermion systems display a variety of ground states. The heavy fermion system $Ce_mTIn_{(3m+2)}$ , where T = Co, Rh & Ir , m = 1, 2 shows superconductivity at different pressure with very low $T_c$. So understanding of its properties like what drives these heavy fermion systems to show superconductivity is very important.

The purposes of this project are:

(1) My purpose is to study its electronic structure, band dispersion and Fermi surface topology in its normal and superconducting states by high-resolution Angle-Resolved Photoelectron Spectroscopy (ARPES). Which can explain the origin of the heavy-fermion ground state in these compounds.

(2) A study of systematic temperature variation band dispersion can focus much more clear idea on the understanding of its various type of ground states responsible of its properties.

| 研究計画 | 研究経費との関連も含めて、何をどこまで明らかにしようとするかがわかるように焦点を絞り、箇条書きで記入すること。<br>また、設備備品費又は旅費が９０％を超える場合は、研究計画の特殊性ないし特殊事情について記入すること。 |
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The Heavy-fermion compounds $Ce_mTIn_{(3m+2)}$, where T = Co, Rh and Ir , m = 1, 2 have relatively high transition temperature $T_c$ with quasi-two-dimensional (Q-2D) crystal structure consisting of alternatively $m(CeIn_3)$-layers and $TIn_2$ layers along the c-axis. The mother compound $CeIn_3$ shows superconductivity below $T_c \sim 0.2$ K at a critical pressure $P_c \sim 2.55$ GPa. For m = 1, the $CeRhIn_5$ orders anti-ferromagnetically below $T_N \sim 3.8$ K and shows superconductivity with $T_c \sim 2.1$ K under pressure of 1.6 GPa, where as $CeCoIn_5$ and $CeIrIn_5$ compounds exhibit bulk superconductivity with $T_c \sim 2.3$ K and 0.4 K respectively with large electronic specific heat coefficient. For m = 2, $Ce_2RhIn_8$ is antiferromagnet with Neel temperatures of $T_N \sim 2.8$ K but shows superconductivity at high pressure $P_c \sim 1.63$ GPa with $T_c \sim 0.6$ K and $Ce_2CoIn_8$ exhibit superconductivity with $T_c \sim 0.4$ K at ambient pressure where as $Ce_2IrIn_8$ is a paramagnet down to 50 mK with no evidence of a phase transition. High quality single crystals of these compounds are necessary for the ARPES studies and can be obtained by collaborating with other sample maker groups world wise.

My plans for carrying out this project is divided mainly into two parts according to time scale and are as under;

(1) In the first half of the financial year (6 month) I shall collect single crystal from various groups and start experiments in our laboratory. We have an High-Resolution Angle-Resolved Photo Emission Spectrometer (ARPES) in our Laboratory. This ARPES measurement system consists of a SCIENTA SES-2002 photoelectron analyzer and a GAMMADATA high brightness Helium discharge lamp with mono-chromator for He-$I_\alpha$ photon source. Experiments will be performed for these samples placed in an ultrahigh-vacuum (UHV) chamber pumped to a base pressure of less than 2 X $10^{-11}$ Torr. The experiments for band dispersion and Fermi Surface mapping will be done at room temperature initially.

(2) In this first half I shall improve a continuous Helium flow cryostat for sample cooling to carry out experiments at low temperature. Since these heavy-fermion system shows superconductivity at very low temperature (less than 4.2 K) so it is necessary to achieve very low temperature. This low temperature can be achieved by the technique of lowering the boiling point of liquid Helium. And this low temperature liquid Helium is transferred to the continuous flow cryostat for sample cooling. Depending upon the pumping speed of He at the out-let of the cryostat the temperature of sample goes down gradually. It is very important to keep the Helium reservoir pressure constant to maintain the constant boiling point of Helium. So I improve the low temperature equipments and continuous flow Helium cryostat in this first six months.

(3) In the second half of the year I shall fabricate the cryostat to an external vacuum chamber to reach low temperature. The necessary thermal shield for the cryostat with heater arrangement has to be made. A temperature controller will be used for getting stable temperature at sample end. So that we can do experiments at different temperatures starting from very low temperature to room temperature.

(4) After testing the low temperature system, it will be transferred to our ARPES system for carrying out experiments at different temperatures. In this six months I have planed to study band dispersion and Fermi Surface mapping for these superconducting Heavy-fermion $Ce_mTIn_{(3m+2)}$ system, where T = Co, Rh &Ir, m= 1, 2 at below the boiling point of liquid Helium temperature and with temperature variation up to room temperature for better understanding of various issues related to it.