Speaker, Title and Abstract :
International Conference / School on Machine Learning Physics

Poster

Y206-1 (13 Nov)

Yusuke Endo (Ibaraki University)

"Application of sparse ICA to fMRI data and performance analysis based on statistical mechanical method"

Matrix factorization is an important topic in machine learning and has applications in neuroscience. In our previous work, we showed that temporal features in functional magnetic resonance imaging (fMRI) data synchronizing to human task can be extracted by applying matrix factorization with sparsity. Based on this result, we propose a novel independent component analysis (ICA), which is a method of matrix factorization with statistical independence and sparsity. Then we apply the proposed method to fMRI data and discuss the performance of feature extraction. In addition, we attempt to conduct a theoretical performance analysis by Thouless-Anderson-Palmer formalism in spin-glass theory.

Y206-2 (13 Nov)

John MOLINA (Kyoto University)

"Physics Informed Machine Learning for Flow Inference "

We develop a Physics Informed Gaussian Process (GP) regression framework to infer the solution to arbitrarily complex Stokes Flow problems. This is done by directly encoding the physics, ie.., the Stokes and continuity equations, into the GP Kernels. Our method allows us to reconstruct flows given sparsely sampled and/or noisy data, which makes it ideal for analyzing experimental flow measurements (e.g., particle image velocimetry data).

Y206-3 (13 Nov)

Takahiro S Yamamoto (Nagoya University)

"Deep learning for black hole ringdown gravitational waves"

The black hole perturbation theory predicts that a black hole (BH) has quasi-normal modes (QNMs). According to General relativity (GR), QNM complex frequencies are determined by the BH mass and spin. If we evaluate the QNM frequency from the BH ringdown gravitational waves, it is useful for testing gravity. I will present the deep learning technique for the ringdown gravitational waves toward the test of GR.

Y206-4 (13 Nov)

Tomoya Naito (RIKEN iTHEMS)

"A simple method for multi-body wave function of ground and low-lying excited states using deep neural networ"

We propose a method to calculate wave functions and energies not only of the ground state but also of low-lying excited states using a deep neural network and the unsupervised machine learning technique. For systems composed of identical particles, a simple method to perform symmetrization for bosonic systems and antisymmetrization for fermionic systems is also proposed.

Y206-5 (13 Nov)

Angelo Giorgio Cavaliere (Cybermedia Center, Osaka University)

"Spatially heterogeneous learning in a deep student machine by message passing"

Recently a replica theory for a deep neural network (DNN) consisting of perceptrons has been proposed [1], suggesting learning in a DNN happens in a highly heterogeneous manner. The analysis shows a hierarchical free-energy landscape that varies in space, implying that layers close to the boundaries are more constrained than the central ones, which eventually enter a liquid phase if the network is deep enough. This also affects the relaxation dynamics of greedy Monte Carlo simulations [2], where is found that deep enough systems relax faster. We extend the theoretical and numerical analysis of the model by applying message passing techniques to a deep network of perceptrons in the simple Bayes optimal teacher-student setting. [1] Hajime Yoshino, SciPost Phys. Core 2, 005 (2020) [2] Hajime Yoshino, arXiv:2302.07419 (2023)

Y206-6 (13 Nov)

Hajime Yoshino (Cybermedia Center, Osaka University)

"Statistical mechanics of a deep neural network"

We present our recent works on the statistical mechanics of a deep neural network based on replica theory and numerical simulations. We found learning in the deep network exhibits strong heterogeneity in space with a liquid phase in the center. Somewhat surprisingly the generalization ability of the system survives even in infinitely deep limits. When replica symmetry breaking (RSB) takes place, the hierarchy of RSB becomes renormalized going toward the center. [1] H. Yoshino, SciPostPhys Core 2, 005 (2020), [2] H. Yoshino, to appear in Phys. Rev. Research (preprint arXiv:2302.07419)

Y206-7 (13 Nov)

Gakuto,Ogiwara (Department of information Systems, Saitama Institute of Technology)

"Solitons Solved by Neural Network"

In this study, we obtain soliton solutions numerically by using neural networks. The application of neural networks to find the solution of differential equations has been studied for many years. However, the application to find soliton solutions has not been studied enough so far. In this study, we propose a neural network method to find soliton solutions such as kink solutions of the ϕ^4 theory and the Sine-Gordon theory, Skyrmion of the Skyrme model.

Y306-1 (13 Nov)

Koshiro Matsuo (Department of information Systems, Saitama Instiute of Technology)

"Constructing emergent spacetime dual to condensed matter system by neural network"

By using a Neural Network model in which the dataset is given by the response functions of a condensed matter system, we numerically obtain an emergent spacetime of a holographic gravity system dual to the condensed matter system. We have noticed that the NN model based on the discretization of spacetimes using the Euler method lacks sufficient accuracy, so we propose using a novel NN model that is based on the Runge-Kutta method to attain more accuracy to reconstruct the holographic spacetime.

Y306-2 (13 Nov)

Hideyuki, Miyahara (Hokkaido University)

"Vicsek Model Meets DBSCAN: Cluster Phases in the Vicsek Model"

The Vicsek model, which was originally proposed to explain the dynamics of bird flocking, exhibits a phase transition with respect to the absolute value of the mean velocity. Although clusters of agents can be easily observed via numerical simulations of the Vicsek model, qualitative studies are lacking. We study the clustering structure of the Vicsek model by applying DBSCAN, a recently-introduced clustering algorithm, and report that the Vicsek model shows a phase transition with respect to the number of clusters: from O(N) to O(1), with N being the number of agents, when increasing the magnitude of noise for a fixed radius that specifies the interaction of the Vicsek model. We also report that the combination of the order parameter proposed by Vicsek et al. and the number of clusters defines at least four phases of the Vicsek model.

Y306-3 (13 Nov)

Yoshihiro Michishita (RIKEN)

"Reinforcement learning of the construction of appropriate frames Toward Alpha Zero For Physics "

Scale separation is one of the keywords of theoretical analysis in physics. To find the scale separation, we need to find the appropriate frame in which the scale separation is apparent. By the way, the transformations to the appropriate frame can be described by trees, and therefore, the problem can be mapped to the board game. In this work, we map the problems of physics to the boardgame and find the best strategy in it by the algorithm of Alpha Zero.

Y306-4 (13 Nov)

Satsuki Nishimura (Kyushu University)

"Exploring the flavor structure of quarks and leptons with reinforcement learning"

We propose a method to explore the flavor structure of quarks and leptons with reinforcement learning. As a concrete model, we utilize a basic policy-based algorithm for models with U(1) flavor symmetry. By training neural networks on the U(1) charges of quarks and leptons, the agent finds some models to be consistent with experimentally measured masses and mixing angles of quarks and leptons. In particular, the normal ordering of neutrino masses is well fitted with the current experimental data in contrast to the inverted ordering. A specific value of effective mass for the neutrinoless double beta decay and a sizable leptonic CP violation are predicted by autonomous behavior of the agent. This presentation is based on arXiv:2304.14176.

Y306-5 (13 Nov)

XiaoXu, DONG (BeiHang University and the University of Tokyo)

"NP-BNN models in nuclear charge radii study"

A Bayesian neural network (BNN) based approach with six inputs including the proton number, mass number, and engineered features associated with the pairing effect, shell effect, isospin effect, and "abnormal" shape staggering effect, is proposed to accurately describe nuclear charge radii. The standard root-mean-square (rms) deviation is 0.014 fm for both the training and validation data. In particular, the predicted charge radii of proton-rich and neutron-rich calcium isotopes are found in good agreement with data.

Y306-6 (13 Nov)

Toshihiro, Ota (CyberAgent, Inc.)

"iMixer: hierarchical Hopfield network implies an invertible, implicit and iterative MLP-Mixer"

Recent studies on modern Hopfield networks suggest the correspondence between certain energy-based associative memory models and Transformers or MLP-Mixer, and shed some light on the theoretical background of the Transformer-type architectures design. In this work we generalize the correspondence to the recently introduced hierarchical Hopfield network, and find iMixer, a novel generalization of MLP-Mixer model. Unlike ordinary feedforward neural networks, iMixer involves MLP layers that propagate forward from the output side to the input side. We characterize the module as an example of invertible, implicit, and iterative mixing module.

Y306-7 (13 Nov)

Takeru Yokota (RIKEN iTHEMS)

"Machine learning to solve functional renormalization group"

Recent developments in machine-learning techniques to solve high-dimensional differential equations open the possibility of solving functional differential equations numerically, which has seemed infeasible without drastic restrictions of input functions before. I will apply the techniques to the derivation of effective actions in field theory. In my method, the effective actions are modeled by neural networks and trained to satisfy the Wetterich equation, which is a functional differential equation known in the context of functional renormalization group. I will demonstrate its accuracy and scalability in a zero-dimensional multi-component model.

Y206-1 (14 Nov)

Yusuke Miyajima (Waseda University)

"Machine-learning detection of the Berezinskii-Kosterlitz-Thouless transition and the second-order transition in two-dimensional spin models"

We proposed two machine-learning methods based on neural networks for detecting the Berezinskii-Kosterlitz-Thouless transition and the second-order transition in two-dimensional classical spin models: q-state clock models and XXZ models. Our methods have advantages over the conventional Monte Carlo methods in terms of computational cost and generality. Moreover, our methods require no or less prior knowledge of the models and no or less future engineering with preprocessing of input data compared with previously proposed machine-learning methods.

Y206-2 (14 Nov)

Toshiaki Aida (Okayama University)

"Analytical Performance Evaluation of Image Restoration via Sparse Coding"

Sparse coding is one of the most effective signal processing methods based on the sparse representation of inferred data, in which dictionary matrices play an essential role as a set of overcomplete basis vectors. In this work, we analytically evaluate the performance of image restoration via sparse coding, utilizing the replica method of statistical physics. Our analysis has made clear, for example, the scaling relation between the complexity of images and the optimal aspect ratio of dictionary matrices, which has ever been addressed not in an analytical way but only in a numerical one.

Y206-3 (14 Nov)

Yue Shen (The University of Tokyo)

"SPIGAN: A generative adversarial network supervised by sparse identification to learn governing equations from scarce data "

This work introduces SPIGAN to discover governing partial differential equations from scarce data for nonlinear spatiotemporal systems, which leverages the strengths of GAN-based neural networks for physics embedding, automatic differentiation, and data generation, along with the advantages of sparse identification in identifying key derivative terms in an end-to end manner. The efficacy and robustness of SPIGAN are demonstrated with Burgers' equation under different parameter settings. The ablation tests further highlight the advantages of SPIGAN over original sparse identification or GAN approaches.

Y206-4 (14 Nov)

Jun-ichiro Ohe (Toho University)

"Machine Learning on the topological spin wave in magnonic crystal"

We study the image recognition on the topological spin wave in magnonic crystal. The amplitude of the spin wave function is used as an image for the machine learning. The topological and non-topological phase are distinguished by using the image recognition algorithm.

Y206-5 (14 Nov)

Suyog, Garg (RESCEU, The University of Tokyo)

"Convolutional Neural Network model for Gravitational-Wave detection from eccentric Compact Binary sources"

The traditional method of Gravitational Wave (GW) detection is Matched Filtering that was used for the first GW detection by aLIGO1 in 2015. The method works by matching the observation data sample with a set of templates of known GW waveforms. For relatively complex GW signals the template bank can have a large set of parameters, for instance for sources with eccentric binary orbits or when including spin-precession effects. Iterating through all the templates during Matched Filtering increases the overall computational cost and time complexity. In recent year, Machine Learning techniques have been probed as a solution to this problem. In this thesis, we present a new Convolutional Neural Network model for detection of GW signals from Neutron Star Black Hole (NSBH) binaries in Real and Gaussian noise. We use NSBH signals simulated using appropriate LALsuite waveform approximants for training the model. For the Real noise, we extract detector noise segments from O3a observation runs using the Gravitational-Wave Open Science Center data. We first make a comparative study on the effects of using different training strategies in the model detection sensitivity. Our model is able to classify input samples as noise or signal with high sensitivity even at low False Alarm Rate. We then train and test the model with GW waveform samples from eccentric NSBH sources. The orbital eccentricity value is uniformly sampled in the range [0.0,0.9]. We finally report our results on using Machine Learning techniques for detection of complex GW signals, focusing our attention on Gravitational Waves from eccentric compact binaries.

Y206-6 (14 Nov)

Kaito Takanami (The University of Tokyo)

"Parameter Estimation of Anisotropic Diffusion Using the EM Algorithm"

Particles within ellipsoidal structures in biological systems are known to exhibit non-Gaussian statistics. In this study, we addresse the problem of estimating diffusion coefficients from the trajectory of a single particle's center of mass using the EM algorithm. We theoretically analyzed the estimation limits, and conducted analyses on actual experimental data.

Y206-7 (14 Nov)

Tomoei Takahashi (Institute for Physics of Intelligence, The University of Tokyo)

"An Empirical Bayes Approach to Estimate the Chemical Potential of Water in Protein Design Problem"

Protein design is the inverse problem of protein structure prediction. We have approached this problem using Bayesian learning. In our previous studies, we introduced the chemical potential of the water surrounding the protein as a hyperparameter. In this study, we propose a method to estimate the chemical potential of water by maximizing the marginal likelihood (MML) using belief propagation. One of our findings is that protein structures that achieve global and local maximum of MML at a certain chemical potential have fewer hydrophobic contacts than the average.

Y306-1 (14 Nov)

Ashish Joshi (Kyoto University)

"Neural network quantum states and quantum skyrmions"

We investigate the static and dynamic properties of quantum skyrmions using neural network quantum state as a variational ansatz. In particular, we study the ground states of a two dimensional quantum Heisenberg model in presence of the Dzyaloshinskii-Moriya interaction. We show that the ground state accommodates quantum skyrmions for a large range of Hamiltonian parameters. These quantum skyrmions, like their classical counterparts, can be put into motion using magnetic fields. This manipulation of quantum skyrmions make them an attractive candidate for spintronic devices. Our work demonstrates that neural network quantum states can be efficiently used to describe quantum magnetism of large systems.

Y306-2 (14 Nov)

Shang-Fu, Wei (The University of Tokyo)

"Vector boson fusion versus gluon-gluon fusion Higgs boson production with full-event deep learning: Toward a decay-agnostic tagger"

We study the benefits of jet- and event-level deep learning methods in distinguishing vector boson fusion (VBF) from gluon-gluon fusion (GGF) Higgs production at the LHC. We show that a variety of classifiers (CNNs, attention-based networks) trained on the complete low-level inputs of the full event achieve significant performance gains over shallow machine learning methods (BDTs) trained on jet kinematics and jet shapes, and we elucidate the reasons for these performance gains. Finally, we take initial steps toward the possibility of a VBF vs GGF tagger that is agnostic to the Higgs decay mode, by demonstrating that the performance of our event-level CNN does not change when the Higgs decay products are removed. These results highlight the potentially powerful benefits of event-level deep learning at the LHC.

Y306-3 (14 Nov)

Tomohisa Okazaki (RIKEN AIP)

"Scientific Machine Learning for Geophysical Modeling"

I present two applications of machine learning methods that incorporate physical laws to geophysical modeling. The first topic is forward modeling of crustal deformation caused by earthquakes, for which we adapted physics-informed neural networks to obtain solutions in discontinuous domains (Okazaki et al. Nat. Comm. 2022). The second topic is inverse modeling of crustal stress state from earthquakes data, for which we formulated an inversion method based on Gaussian processes (Okazaki et al. J. Geophys. Res. 2022).

Y306-4 (14 Nov)

Koji Inui (The University of Tokyo)

"Inverse Hamiltonian design using automatic differentiation: the applications to band topology and quantum entanglement"

Solving the inverse problem to identify Hamiltonians with desired properties holds promise for the discovery of new principles and materials. We develop a general framework for the inverse problem using automatic differentiation. We demonstrate the generality of this framework by applications to i) a tight-binding Hamiltonian which maximizes the anomalous Hall conductivity, ii) a spin-charge coupled Hamiltonian which maximizes the photocurrent induced by solar radiation, and iii) a quantum spin Hamiltonian to maximizes quantum entanglement. These applications show that our framework could accelerate materials research by automating the construction of models and principles.

Y306-5 (14 Nov)

Filippo Vicentini (Ecole Polytechnique and College de France)

"Recent Advances in Neural Quantum Dynamics "

In this talk I will discuss recent advances in the simulation of the dynamics of quantum systems using Neural Quantum State. In particular, I will discuss how the standard approach based on the time-dependent variational principle (TDVP) has a fundamental bias arising from Monte-Carlo sampling, which prevents it to describe states with several zeros or nodes. Then, I will introduce a new algorithm based on infidelity minimization that can circumvent those problems, and show its application to the study of entanglement phase transition in 2D lattices of measured spins. Finally, I will discuss how those advances in our understanding of closed systems can be applied to the simulation of open systems driven out of equilibrium, re-analysing some past results of mixed-states Lindblad dynamics.

Y306-6 (14 Nov)

Tomohiko Konno (Kansai-Gakuin)

"Deep Learning Model for Finding New Superconductors"

We will discuss the deep learning model and methods for discovering new superconductors

Y306-7 (14 Nov)

Mikiya, Doi (Graduate School of Information Sciences, Tohoku University)

"Statistical mechanical analysis of signal recovery phase transition in binary compressed sensing"

Compressed Sensing (CS) is a signal-processing technique to reconstruct high-dimensional sparse signals from a few observations. The asymptotic theoretical performance of CS has been studied using approaches based on statistical mechanics, such as the spin-glass theory. Recently, Binary Compressed Sensing (BCS), which assumes the original signal to be binary, has gained attention. However, in most cases, studies on performance limits have been analyzed by relaxing discrete values to continuous ones. We present results evaluating the difference in performance limits between reconstructing as discrete values and relaxing to continuous values using the replica method, a statistical mechanical approach.

Y206-1 (15 Nov)

Ryu Watarai (Osaka Metropolitan University)

"Development of Accelerator Tuning System Using Machine Learning: Development of Accelerator Simulator"

We have developed a machine-learning-based operation tuning scheme for the KEK e-/e+ injector linac (Linac). In order to apply machine learning to accelerator control, pre-training using a realistic accelerator simulator is required. For the pre-training, we have developed a 1000-parameter accelerator simulator based on dimensionality reduction. In this paper, we show the current status of the development of the accelerator simulator, and evaluation test results of the simulator.

Y206-2 (15 Nov)

Seiya, Miyamoto (Tohoku University)

"Application of a machine-learning-assisted Markov Chain Monte Carlo Method to a NP-hard problem"

The Markov chain Monte Carlo (MCMC) method is a versatile approach to sample a given distribution. Recent studies have shown that machine learning techniques can resolve the slow convergence in the local algorithms. Here, we employ an autoregressive neural network to devise an efficient MCMC algorithm and apply it to a NP-hard problem; the maximum independent set (MIS) problem. We measure the autocorrelation time of our algorithm and compare it with a simple local algorithm.

Y206-3 (15 Nov)

Tomokatsu, Onaga (Kyushu University)

" Dynamics of social spread: a game theoretic approach"

New ideas and technologies adopted by small number of people ocassionally spread globally through social connections. Spread on social networks was stuided as complex contagion in statistical physics, while it was studied as network game in economics. In this study, we analyze game theory on networks. First, we point out that Watts threshold model and a coordination game are in the same class. Second, we derive a Nash equilibreum using a message-passing method. Third, we prove the existence and convergence of the solution.

Y206-4 (15 Nov)

Norihiro Hizawa (Kyoto University)

"Latent variables for nuclear shape dynamics in multi-task learning"

A microscopic description of nuclear fission remains a paramount challenge in nuclear theory. Conventionally, phenomenological ansatzes with multipole moments have been employed to characterize nuclear shapes. Here, we present a novel method combining supervised learning and an autoencoder to derive latent variables that characterize low-energy dynamics of nuclear deformation. Applying this method to uranium isotope, we successfully extract latent variables, indicating that the conventional assumptions carry only limited information on the dynamics. By successfully extracting latent variables which are consistent with the dynamics, we expect that data-driven approaches with deep learning will significantly advance our microscopic understanding of nuclear fission.

Y206-5 (15 Nov)

Shion Sasaki (Graduate school of information Sciences, Tohoku university)

"Neural Network as Quadratic Unconstrained Binary Optimization"

Deep learning has seen increased practical application in recent years, but its limited output interpretability presents challenges in some domains. Our research partially addresses this issue by approximating a deep neural network (DNN) as a quadratic unconstrained binary optimization (QUBO) problem. We formulate a ReLU-based neural network as QUBO, suitable for quantum annealing. This approach enables us to infer input to match the desired output. It holds promise for verifying neural networks in safety-critical applications like autonomous driving.

Y206-6 (15 Nov)

Ayaka Sakata (The Institute of Statistical Mathematics)

"Prediction errors based on approximate message passing"

Approximate message passing is an algorithm for calculating marginal probabilities. We discuss how to quantify prediction errors based on the approximate message passing algorithm.

Y206-7 (15 Nov)

Akira Tokiwa (Kavli IPMU)

"Enhancing Resolution in HEALPix Maps for Dark Matter Simulations"

To test cosmological models, high-resolution simulations are essential but computationally costly. Our study focuses on minimizing this computational burden. By employing generative AI techniques, we can efficiently measure the cosmological model's covariance. We trained a super-resolution diffusion model using 100 paired low-resolution to high-resolution HEALPix maps, offering a more efficient approach to achieving high-resolution dark matter simulations.

Y306-1 (15 Nov)

Naoki Koyama (Niigata university)

"Visualization of Estimation Basis for Transient Noise Classification in Gravitational Wave Detectors Using Machine Learning"

Classifying transient noise in gravitational wave detectors is crucial for identifying the noise sources and providing insights for improving detector performance. The demand for machine learning in this classification is increasing. However, the basis on which image classification by machine learning operates is not always clear. In this study, we developed a CNN model to classify transient noise and visualized the estimation basis to enhance its reliability.

Y306-2 (15 Nov)

Hirotaka Takahashi (Tokyo City University, Japan)

"Classification of Glitch Noise and Burst Gravitational Wave Search with machine learning technique"

Gravitational wave predicted by General Relativity has recently become observable. In gravitational wave observation, non-stationary and non-Gaussian noise, called "transient noise", frequently appear. It is known that the transient noise might cause the instabilities in the detector. This study employed the deep learning to extract latent variables of transient noise and classify transient noise. We also apply a convolutional neural network to detect and classify bust gravitational waves from core-collapse supernovae.

Y306-3 (15 Nov)

Naoto Nakano (Meiji University)

"Path integral approach to universal dynamics of reservoir computers"

We study a characterization of the reservoir computer (RC) by the probability distribution of coupling constants of the random network. Utilizing the path integral method, we elucidate random network dynamics, leading to a classification of networks based on the coupling constant distribution function and the eigenvalue distribution of the matrix of the coupling constant. The findings suggest a correlation between the RC's computational capacity and network parameters across universality classes. Numerical simulations reveal superior computational performance near phase transitions. This work provides novel insights for designing RCs.

Y306-4 (15 Nov)

Jiuding Duan (Allianz Global Investors)

"TBA"

TBA

Y306-5 (15 Nov)

Koji, Kobayashi (Sophia University)

"Drawing phase diagrams from wavefunctions in topological systems with random potential using Vision Transformer"

One of the typical applications of image recognition in solid-state physics is the phase classification of random systems. Conventionally, image recognition has been based on convolutional neural networks (CNNs). However, Vision Transformer (ViT) is now considered a better method. In this study, we compare the performances of ViT and CNN for the classification of wavefunctions in random systems.

Y306-6 (15 Nov)

Tomohiro Otsuka (Tohoku University)

"Automatic state recognition of quantum dot hardware utilizing machine learning"

Semiconductor quantum dots are good candidates for quantum bits for quantum information processing. To realize large-scale quantum systems, automatic state recognition and optimization of quantum dot hardware are important. We studied such automatic state recognition by convolutional neural networks. By preparing various learning data by simulation, we realize a state estimator which works on real experimental data. We also analyzed the operation by visualizing the important regions for the estimation.

Y306-7 (15 Nov)

Dita Puspita Sari (Shibaura Institute of Technology)

"muSR Study of Hole-Doped Organic Metals: Superconductivity Nearby Quantum Spin Liquid States"

The hole-doped organic metal k-(ET)4Hg3-dBr8, d = 11% (k-HgBr) and k-(ET)4Hg3-dCl8, d = 22% (k-HgCl), where ET=(CH2)2S8C6S8(CH2)2, are exceptional carrier-doped metal among half-filled organics, beside ET dimers (S = 1/2) tend to arrange triangular lattice. k-HgBr undergoes superconductor while k-ET-HgCl transitions to the insulator at ambient pressure and becomes superconductor under pressure. k-HgBr is discussed as a doped quantum spin liquid metal because, although it is superconductor at ambient pressure the magnetic susceptibility behavior is well scaled to that of organic spin-liquid insulator, k-(ET)2Cu2(CN)3. Further, k-HgBr shows non-Fermi liquid (NFL) behavior evidenced by linear temperature dependence of resistivity, supported by 13C-NMR and muon spin rotation (muSR) spectroscopies. The further specific heat and 13C-NMR studies showed both compounds have a large residual heat capacity and close to quantum critical point. In such case muSR convinced the time-reversal symmetry in the superconducting k-HgBr. We are characterizing superconductivity in k-HgBr and spin dynamics in k-HgCl, which may lead to the degree of quantum entanglement, by using muSR.