Results of research

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We have classified all spacetimes with a closed rank-2 conformal Killing-Yano (CKY) tensor. It is shown that the D-dimensional Kerr-NUT-de Sitter spacetime constructed by Chen-Lü-Pope is the only spacetime admitting a non-degenerate closed CKY tensor ([21] of Publication List). For spacetimes with general closed CKY tensor, they give a generalization of Kerr-NUT-de Sitter (KNdS) spacetimes. The metric of the generalized KNdS spacetime is a metric of the fiber space whose base spaces are several Kähler spaces and at most one general space, and its fiber is the KNdS space ([24, 25]).

It is shown that the Dirac equations in general higher dimensional Kerr-NUT-de Sitter spacetimes are separated into ordinary differential equations ([22]).

In the generalized Kerr-NUT-de Sitter spacetime, it is shown that certain type of tensor perturbation admits separation of variables and the linearized Einstein equation (the Lichnerowicz equation) turns into ordinary differential equations ([26]). These ordinary differential equations contain the information of eigenvalues of the gauge-covariant Lichnerowicz operator on the base complex projective spaces. The form of eigenvalues has been guessed for rank-2 tensors. But the range of them is not determined. We have determined the eigenvalues of the gauge-covariant Lichnerowicz operator on $\mathbb{C}P^n$ and their multiplicities not only for rank-2 tensors, but for general rank-r tensors ([32]).

We consider β-deformation of the quiver matrix models in the light of the recent progress on 2d-4d connection of conformal field theories, in particular, the Alday-Gaiotto-Tachikawa (AGT) conjecture. A quantum spectral curve is introduced in the case of $SU(n)$ quiver matrix model. Residue analysis is provided both for the curve of the $SU(n)$ matrix model with the "multi-log" potential and for the Seiberg-Witten curve in the case of $SU(n)$ with $N_f = 2n$ flavors, leading to the matching of the mass parameters. The isomorphism of two curves is made manifest ([27]).

We observe that the Dotsenko-Fateev integral representation of the conformal block of 2d conformal field theory can be interpreted as a β-deformed matrix model of Selberg type. Using the formula associated with the Jack polynomials, we established the method of generating q-expansion coefficients for conformal block and Nekrasov function for $\mathcal{N} = 2$ supersymmetric $SU(2)$ gauge theory with four flavors ([28]).

We then consider a series of massive scaling limits of the β-deformed matrix model of Selberg type ($SU(2)$ with $N_f = 4$) which reduce the number of flavors to $N_f = 3$ and subsequently to $N_f = 2$ ([29]).

We consider β-deformed quiver matrix model based on the affine Lie algebra $A_n^{(1)}$. The Virasoro constraint of this model is determined. For $n = 1, 2$ cases, the explicit forms of the loop equations are obtained ([30]).