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Membership of academic societies:
The Physical Society of Japan (JPS),
The Mathematical Society of Japan (MSJ)

Research Interest:

- Mathematical Physics
- Gauge Theory related to String Theory
- Noncommutative Solitons

Research Summary:

For the last several years, I have mainly studied extension of soliton theories and integrable systems to noncommutative (NC) spaces. This is not just a generalization but expected to be a fruitful direction in both physics and mathematics. In gauge theories, especially, noncommutative extension corresponds to introduction of background flux and has been applied to the corresponding physical situations such as the quantum Hall effects in background magnetic flux. Furthermore, in noncommutative spaces, singularities could be resolved and therefore new physical (smooth) objects could appear. For example, $U(1)$ instantons are one of such new objects which come from resolution of singularity in the (instanton) moduli spaces of the anti-self-dual Yang-Mills equations in four dimensional noncommutative Euclidean spaces. This is also due to the fact that the ADHM construction can work well in the noncommutative settings, and in this sense, integrability is also preserved (e.g. [1]).

Noncommutative solitons actually describe D-branes themselves in some D-brane configurations, which makes us to analyze various properties of D-branes by analyzing those of noncommutative solitons. The latter is sometimes much easier than the former and long-standing problems on D-branes such as Sen's conjecture have been exactly solved.

After the development of noncommutative solitons in the effective theories (in gauge theories) of D-branes, noncommutative extension of lower-dimensional soliton equations (e.g. KdV eq. in scalar theories) had been also studied intensively (e.g. [2]). In [3], it is proved that many of such lower-dimensional noncommutative soliton equations can be derived from the 4-dimensional noncommutative anti-self-dual Yang-Mills equation by reduction. This result implies that the lower-dimensional soliton equations also belong to gauge theories in this context, and hence have the corresponding physical situations with background flux. These soliton equations can be embedded to the $N = 2$ strings and can be applied to them via analysis of the exact soliton solutions.

In [4], we find a Bäcklund transformation for the noncommutative anti-self-dual Yang-Mills equation and construct wide class of new solutions including not only noncommutative instantons (finite-action solutions) but infinite-action solutions. These solutions can be represented in terms of the quasideterminants in very compact forms. This is in common with the lower-dimensional soliton equations (e.g. [5]) and I look for a universal formulation of integrable systems which unified the higher-dimensional and the lower-dimensional integrable (soliton) equations.

Major Publications:

[1] M. Hamanaka and T. Nakatsu, "ADHM Construction and Group Actions for Noncommutative Instantons," in preparation (2013).

[2] M. Hamanaka, "Noncommutative Solitons and Integrable Systems," hep-th/0504001.

[3] M. Hamanaka, "Noncommutative Ward's Conjecture and Integrable Systems," Nuclear Physics B **741** (2006), 368 – 389 [hep-th/0601209].

[4] C. R. Gilson, M. Hamanaka and J. J. C. Nimmo, "Bäcklund Transformations and the Atiyah-Ward ansatz for Noncommutative Anti-Self-Dual Yang-Mills Equations," Proceedings of the Royal Society A **465** (2009), 2613 – 2632 [arXiv:0812.1222].

[5] M. Hamanaka, "Noncommutative Integrable Systems and Quasideterminants," [arXiv:1012.6043].

Education and Appointments:

2003 Ph.D at the University of Tokyo, Department of Physics
2003 JSPS postdoctoral fellow at the Univ. of Tokyo (Komaba)
2004 Assistant Professor, Nagoya University
(2005/8-2006/12: Visiting Researcher, Univ. of Oxford)
(2008/10-2009/2: Visiting Researcher, Univ. of Glasgow)

Message to Prospective Students:

I would be interested in mathematical structure behind the fundamental law of nature, currently, quantum field theory and string theory. Any student is welcome to discuss with me. (Please note that I am not a mathematician but a physicist.)

I have been an adviser of five graduate students so far. In the case of a main adviser (twice), I have had a meeting or an informal seminar to help them once per one or two weeks. The following lists are a part of the relevant papers.

[1] P. Etingof, I. Gelfand and V. Retakh, "Factorization of differential operators, quasideterminants, and nonabelian Toda field equations," Math. Res. Lett. **4**, 413 (1997) [q-alg/9701008].

[2] K. Ueno and K. Takasaki, "Toda lattice hierarchy," Adv. Stud. Pure Math. **4**, 1 (1984).

[3] S. A. Cherkis and R. S. Ward, "Moduli of Monopole Walls and Amoebas," JHEP **1205**, 090 (2012) [arXiv:1202.1294 [hep-th]].

[4] S. A. Cherkis and A. Kapustin, "Hyperkahler metrics from periodic monopoles," Phys. Rev. D **65**, 084015 (2002) [hep-th/0109141].