By Y. Derbenev, Jefferson Lab, USA October 22, 2018

**Review of two proposals on NICA project of JINR:**

**Proposal I. Polarized ions in NICA complex (by A. Kondratenko et al.)**

**Proposal II. Polarized colliding beams in NICA storage ring (by I. Koop et al.)**

I have reviewed these two proposals as I was able to do this. Presumably, based on my information and understanding the related issues and ideas of two proposals, I conclude that Proposal II unlikely to reach the goal associated with the polarized beams part of the NICA program. Therefore I cannot put my reflections simply in frame of pros and cons. On the other hand, I have recognized some advanced suggestions in Proposal II, which, in my view, may be critical in optimizing the luminosity performance. My insights and predominant conclusions are in the following.

**Requirements to polarization features of NICA complex**

* Reveal longitudinal and transverse polarization of ion beams minimum 70% in detectors SPD/MPD, at polarization lifetime about that of the beam or longer;
* Reveal luminosity ~1030-1032 см-2$⋅$с-1 in energy range 2 to 13,5 ГэВ/c;
* Provide scanning in energy with step 1 ГэВ (Drell-Yan, J/Psi) and 0,3 МэВ (high $p\_{T}$ hadron physics, exotic states);
* Provide collider operation in asymmetric mode of two beams;
* Provide Spin Flipping coherent overall the beam.

**My comments after reviewing proposal I**

* ST concept is based on insertion of SC solenoids as full Siberian Snakes in the collider ring.

Inclusion of SS in a ring generally and in principle leads to cancellation of arcs’contribution to the global spin tune, thus making the last one energy independent with a high precision. Spin stability during the acceleration and long term luminosity run has been demonstrated at RHIC of BNL with two snakes per ring in energy range up to 100 GeV. So possibility to preserve coherent spin in NICA rings (with its maximum energy for protons about 13.5 Gev ) can be guaranteed in a prior for all polarized species.

* In energy range of NICA, namely solenoids are adequately feasible technical solution for SS, once there is enough space in the straights.
* Introduction of a single snake/ring could be a suitable approach to preserving of the coherent spin in the collider rings at acceleration and long term maintenance.
* To attain a solution for a non-destructive spin manipulation, authors propose to install two solenoidal SS, one for each of two opposite straights. Such installation makes global spin tune equal to zero, i.e. spin motion totally degenerated and unstable. But spin stability returns with introduction of a relatively small spin rotator designed and operated to provide the ordered direction of the periodic (around the ring) polarization and finite global spin tune value.

Based on these properties of spin dynamics of the ST scheme, collider acquires the following critical features:

* Any desirable beam polarization at detector can be easily set for all species;
* Ease, convenient Flipping Spin coherent overall the beam, by mean of relatively slow periodic adiabatic rotation of the stationary spin direction of the rotator (say, with frequency 1Hz) while keeping spin tune constant.
* Fixation of spin tune in the collider ring is also granting with possibility of acceleration of polarized beam without crossing spin resonances, after pre-acceleration in the Nuclotron to a low energy (4 GeV proton beam).
* Perspective application for high precision studies/experiments with polarized beams

***Corporative comments to Proposal I***

* *Spin Transparence* concept proposed for NICA can be regard as transplantation of the ***figure 8*** spin dynamics concept of the Jefferson Lab EIC (JLEIC) to the racetrack collider ring of NICA.
* The proposed quasi-static spin flipping technique is adopted by the JLEIC project as result of the collaborative studies by the authors of Proposal I and JLEIC design team of JLab.
* By the way, a collaborative JLab-BNL study of the ST ideas and techniques has recently started, with a planned prospect of the experimental tests at RHIC with Siberian Snakes of RHIC modified for ST spin dynamics.

**My comments after reviewing proposal II**

* Proposed agenda is relaying on traditional concepts and techniques of the spin resonance crossing based on the asymptotic Froissart-Stora theory.
* Asymptotic limit may not be achieved in real conditions
* This lack of practical validity becomes especially crucial concerning the highly frequent spin flip required for elimination, with a high accuracy, polarization-related systematic errors. Conventional RF flipping techniques proposed for use in NICA is essentially associated with unavoidable significant loss of the polarization degree after frequent crossing the RF resonance of the spin flipper.
* By the way, I have to mark here an important suggestion in Proposal II ( I.Koop et al.) not related to the polarization topic but concerning the preference of a coasting colliding beam vs the bunched beam collisions. The authors have pointed out that, operating the coasting beams would be an essentially advancing approach for NICA case – in view of the Space Charge and synchronization  problem of the bunch –bunch collisions regime.  They have shown in the proposal that the bunched beams collisions at beam parameters of NICA do not benefit luminosity significantly (or not at all) vs the continuous beams (or barrier bucket driven beams) but somewhat opposite to that.  I share their insights, presumably, at least. Also, to be noted in this connection that, luminosity formulas including coasting beams have been developed in Ref [1]. This issue should be a subject of further comprehensive explorations for optimization of Interaction Region and of NICA.

[1] I.N. Meshkov, “Luminosity of a Collider with Asymmetric Beams”. ISSN 1547-4771, Physics of Particles and Nuclei Letters, 2018, Vol. 15, No. 5, pp. 506–509. © Pleiades Publishing, Ltd., 2018.

***More corporative comments to my review***

* Two proposals do not show common references through the texts and even in the reference lists.
* There are several references in Proposal I to publications on study of the spin-resonance crossing techniques and RF spin flipping by authors of the Proposal I including the study addressed to the NICA polarized beams program.
* I would call for a corporative alliance of two groups which would serve the mutual exchange of the related information and working out the aligned understanding and agreeable specification of the technical proposals.
* Collaboration JLab-Novosibirsk-BNL could be extended by the alliance with the polarized NICA research group – in favor of the related projects with polarized colliding beams.

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Представленный проект коллайдера NICA с двумя соленоидальными змейками позволяет работать с поляризованными пучками в различных режимах в зависимости от включения/выключения змеек..

При выключенных змейках, расположенных в SPD и MPD промежутках, реализуется традиционный PS режим работы практически во всем диапазоне энергий с вертикальной поляризацией в любом месте орбиты коллайдера. Исключение составляют узкие полосы по энергии, где реализуется ST режим на целых спиновых резонансах, в котором возможно получать любую поляризацию в обоих детекторах.

Включение только одной из змеек переводит коллайдер в PS режим со спиновой частотой равной половине. Змейка полностью перестраивает спиновое движение: устойчивая поляризация имеет продольное направление в противолежащем от змейки промежутке. Такой режим успешно использовался при тестировании змеек в 1989 году в индианском университете (USA) на установке IUCF Cooler Ring (Indiana University Cyclotron Facility).

При включении двух соленоидальных змеек коллайдер переводится в уникальный режим спиновой прозрачности, спиновая частота в котором не зависит от энергии и равна нулю. В этом режиме можно получать любую поляризацию в любом месте орбиты.