not yet reliable. We will demonstrate the protein crystallography by June with the improved machine and reduced background.

Keywords: synchrotrons, protein crystallography, EXAFS

## MS.90.5

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### Integrating laser and linac technology for next generation X-ray sources

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We will discuss a superconducting linac-based compact inverse Compton scattering source of hard x-rays appropriate for a university or industry laboratory. The process of inverse Compton scattering, in which an electron of 20-50 MeV backscatters an optical photon into the hard x-ray spectral range, offers the opportunity to produce high-brilliance hard x-ray beams with a laboratory-scale facility. Using a 2-meter superconducting linac and a 1-kW laser system, the time-average brilliance of such beams will be similar to 2nd generation synchrotron facilities. Two important characteristics will make our concept unique in comparison to the best synchrotrons or other compact sources. First, beam size can be below 10 microns, and second, the pulse length can be as short as 100 femto-seconds opening up applications difficult or impossible with even 3rd generation sources. This talk will discuss the conceptual design of such a source and the scientific program it could support, including imaging and crystallography in both static and time-dependent modes.

Keywords: high-power lasers, Compton scattering, synchrotron radiation sources

## MS.91.1

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### Liquid state of spins and charges in geometrically frustrated spinel oxides

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Among a wide variety of structural categories of transition metal oxides, the spinel, generally ex-pressed by the chemical formula $AB_2O_4$, is unique in that an extremely strong geometrical frustration on both “spin” and “charge” channels is anticipated from its pyrochlore B-sublattice, a corner shared network of B-tetrahedra. We have been exploring novel liquid states of spins and charges produced by frustration using spinel structure as a play ground. In this talk, we present recent highlights of such exploration. $Na_4Ir_3O_8$ with S=1/2 $Ir^{4+}$ was discovered. This compound crystallizes in “hyper-Kagome” structure, which can be viewed as a cation-ordered (Ir and Na) spinel structure. We show that the ground state of this system is very likely a three dimensional S=1/2 spin liquid as a consequence of geometrical frustration [1]. $LiV_2O_4$ spinel is a “charge” frustrated system because of the mixed-valent configuration with 1:1 ratio of $V^{3+}$ and $V^{4+}$, where we found a charge analogue of spin liquid state. In this system, the ordering of charges is suppressed completely because of the geometrical frustration and, instead, a heavy-fermion metal with an effective electron mass of $100m_e$ is realized at low temperatures. [2]. A new mixed-valent spinel oxide $LiRh_2O_4$, a Rh-analogue of $LiV_2O_4$, was discovered [3]. We found that, in contrast to $LiV_2O_4$, an orbital ordering associated with cubic to tetragonal transition suppresses frustration and leads to a complex charge ordered state at low temperatures. This waork was done in collaboration with Y.Okamoto, S.Niitaka, M.Nohara, H. Aruga-Katori, P.Jonson, S.Fujiyama and K.Kanoda

[1] Y. Okamoto et al., Phys. Rev. Lett 99, 137207 (2007).
[2] P. Jonson et al., Phys. Rev. Lett.99, 167402 (2007).
[3] Y. Okamoto et al., submitted.

Keywords: spinel, geometrical frustration, liquid state of spins and charges

## MS.91.2

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### Local order and frustration in vanadate spinels

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Orbitally degenerate frustrated spinels, $Cd_{1-x}Zn_xV_2O_4$ were investigated using elastic and inelastic neutron scattering techniques. For the end members, x = 0 and 1, a tetragonal distortion is observed upon cooling through a Jahn-Teller coupling mechanism which leads to the formation of spin chains in the ab-plane. Upon further cooling, Neel ordering is established due to interchain coupling. In the doped compounds, bulk susceptibility shows that the macroscopic transitions to cooperative orbital ordering and long range antiferromagnetic ordering are absent. However, from the inelastic magnetic scattering measurements, it is suggested that the dynamic spin correlations at low temperatures have similar one dimensional characteristics as observed in the pure samples. The pair density function analysis of neutron diffraction data shows that the local atomic structure does not become random with doping but rather consists of two distinct environments corresponding to $ZnV_2O_4$ and $CdV_2O_4$. This suggests that short-range orbital ordering is present which leads to the one dimensional character of the spin correlations even in the low temperature cubic phase of the doped compositions.

Keywords: local symmetry, one-dimensional, orbital degeneracy

## MS.91.3

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### Controlling spin glass entropy - Frustrated magnetism in the spinels

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The zero point entropy of frustrated magnets is an interesting quantity, as it provides information on the degeneracy of their ground states. Indeed, much of the recent work on spin ices was triggered after the characterisation of their zero point entropies using specific