Excellent discussions on the efficacy of EDM searches and the Standard Model are given in refs. [1, 2]. Widespread community support for EDM searches is documented in several reports. For example, the P5 report [3] has stated that the existence of an EDM can provide the “missing link” for explaining why the universe contains more matter than antimatter. Further it states that the non-observation of EDMs to date provides tight restrictions to building theories beyond the Standard Model. The NSAC Long Range Plan [4] further states that a non-zero EDM would constitute a truly revolutionary discovery. The EPP2010 report [5] has stated that participation in small-scale, high-precision measurements should be encouraged in any budget scenario. There is a worldwide quest to discover an EDM in three sectors: the electron (paramagnetic atoms and molecules), the nucleon and the nucleus (diamagnetic atoms). In order to fully understand the origin of a non-zero EDM, it is necessary to measure the EDM in all three systems. Here we report on the status of the Ra-EDM experiment at Argonne, the near term plans, and how the prolific amount of $^{225}\text{Ra}$ production at future isotope facilities such as Project X or FRIB after upgrade, could revolutionize the search for a non-zero electric dipole moment (EDM) in nuclei.

Presently, the best limit [6] on an EDM for the diamagnetic atom is provided by the Seattle group for $^{199}\text{Hg}$. This limit is $3.1 \times 10^{-29}$ e cm at the 95% CL. The primary advantage of $^{225}\text{Ra}$ is the large enhancement [7–9], approximately 1000, of the atomic EDM that arises from both the octupole deformation of the nucleus and the highly relativistic atomic electrons. The scheme at Argonne is to trap $^{225}\text{Ra}$ atoms in an optical dipole trap (ODT) as first suggested in ref. [10]. The ODT offers the following advantages: $\mathbf{v} \times \mathbf{E}$ and Berry’s phase effects are suppressed, scattering is suppressed between cold fermionic atoms, vector light shifts and parity mixing induced shifts are small. The systematic limit from an EDM measurement in an ODT can be controlled at the level [10] of $10^{-30}$ e cm.

During 2007, we demonstrated [11] the first magneto-optical trap (MOT) of Ra atoms. In 2010, we demonstrated the transfer of atoms from the MOT to the ODT with an efficiency exceeding 80%. During this year, we demonstrated the transfer of atoms from the MOT to an ODT some 47 cm from the MOT. During the coming year, we plan a vacuum upgrade that should permit the lifetime of atoms in the ODT to improve from 6 s to 60 s. We expect to begin the first phase of the EDM measurement during 2012. The sensitivity for this phase would be at least $10^{-26}$ e cm with a 1-10 mCi source of $^{225}\text{Ra}$, which should be competitive with $10^{-29}$ e cm for $^{199}\text{Hg}$ in terms of sensitivity to T-violating physics.

For phase 2 of this experiment, we plan to upgrade the optical trap. In the present MOT, the slower and trap laser operate at 714 nm where there is a relatively weak transition rate. In phase 2, we would upgrade the trap to operate at 483 nm where a strong transition can be exploited for slowing and trapping. The expected improvement is at least an order of magnitude more trapped atoms and perhaps even higher.

The apparatus is relatively compact as shown in Fig. 1 and consequently is “portable”. Thus the experiment could be located in close proximity to an accelerator, if necessary. Project X is expected [12] to produce more than $10^{13} \text{Ra}$ atoms/s. In this case it should
TABLE I: Projected sensitivities for $^{225}$Ra and $^{199}$Hg equivalent for three scenarios

<table>
<thead>
<tr>
<th>Phase</th>
<th>Phase 1</th>
<th>Phase 2 (upgrade)</th>
<th>Project X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ra (mCi)</td>
<td>1-10</td>
<td>10</td>
<td>&gt; 1000</td>
</tr>
<tr>
<td>Sens. $^{225}$Ra ($10^{-28}$ e cm)</td>
<td>100</td>
<td>10</td>
<td>0.1-1</td>
</tr>
<tr>
<td>Sens. $^{199}$Hg ($10^{-30}$ e cm)</td>
<td>10</td>
<td>1</td>
<td>0.01-0.1</td>
</tr>
</tbody>
</table>

FIG. 1: Schematic diagram of the EDM setup (left) and photograph of the installation at Argonne National Laboratory (right)

be possible to extract more than 1 Ci of $^{225}$Ra for use in the EDM apparatus. This would lead to a projected sensitivity of $10^{-28} - 10^{-29}$ e cm for $^{225}$Ra, competitive with $10^{-31} - 10^{-32}$ e cm for $^{199}$Hg. The table summarizes the projected phases and sensitivities.

In summary, The high intensity of radium atoms from Project X in conjunction with newly-developed, high-efficiency optical trapping methods for Ra should provide unprecedented reach in the search for a nuclear EDM.

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