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About Neutron Electric Dipole Moment: Exotic Case.

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The main motivation to write this paper was that the best current experimental upper limit for neutron electric dipole moment (EDM) obtained at Grenoble[1] is 1.2.10−25 *e*cm while a lot of theoretical predictions (see, for example, reviews of N.S.Ramsey[2] and E.P.Shabalin[3])give values in the range from 10−20 *e*cm to 10−25 *e*cm. The question is: does it mean that this range of EDM is now absolutely excluded? Or in paraphrase: if EDM is really in this range, how it should behave so that the experiments performed by now [1, 4−14] did not ˆsee˜ it? Obviously this approach is addressing some exotic alternatives. One of these could be the following.

In the experiments performed by now it was assumed that **dn** is parallel or antiparallel to spin of neutron **s**, since the orientation of the particle can be specified only by the orientation of its angular momentum. But it is worth to note that while **dn** is a vector, **s** is an axial vector. An axial vector means that we have a plane, a contour on this plane and a certain motion along this contour (left− or right−oriented), for **s** it is the motion of the matter, for magnetic moment **mn** it is the motion of the charge. We can not put a vector on this plane, because we don´t have a specified direction, but we can neither put a vector across the plane because knowing only spin and magnetic moment we know nothing about something what could be across this plane. This is the situation when there is no field and it is illustrated on Fig.1a. But lets put the magnetic field **B** antiparallel to **s**. Then magnetic moment of neutron **mn** will precess around the field **B** and the precession has a phase. This phase traces a selected direction on the plane of precession. In other words: magnetic field breaks symmetry through precession. Now we have a selected direction for neutron whereto we can put a vector. Thus, the only way to specify the orientation of EDM of neutron is that ***the vector dn is rotating in the plane perpendicular to B*** **(**while magnetic moment of neutron is precessing around the field) ***and the frequency of this rotation*** w=wp, here **wp** is the neutron Larmor precession frequency. So EDM arises here as a result of a broken symmetry. This rotation in general can be certainly out of phase with precession because we know nothing so far to fix the difference of phases Dj (this is illustrated on Fig.1b). But if so than it means that the vector **dn** and the axial vector **mn** are tied up together through a phase of the precession and then by applying the moment of forces **dn´ E** we can produce an impact on **mn.** However if to apply a static electric field E first parallel and then antiparallel to B, what was done in previous experiments, it will not interfere with the resonance if Dj =±p/2 because precession ˆholds˜ **dn** in the plane perpendicular to **B** while the torque from **dn´ E** in this case, see Fig.1b, will not affect the neutron Larmor precession frequency for both directions of the electric field1. From here it follows that to agree with the results of experiments [1, 12] one should assume that Dj =±p/2.

Now, how to measure **dn** and Dj? If the vector **dn** and the axial vector **mn** are tied together, it will be possible to cause a spin flip by means of the oscillating electric field E=E0sin(wpt) applied in direction perpendicular to B, this is illustrated on Fig.2. By rough estimates for E0~104 V/cm and **B**

=10mG it would be possible to cause a spin flip if dn >10−20 *e*cm. Here the duration of E−pulses of a Ramsey time−separated oscillatory field technique, applied to E−field, was taken about 10 sec and wp about 30 Hz close to the values used in experiment[1]. The analyses of resonance curve will probably enable to reach a level of 10−22 *e*cm if a displacement current and an induced magnetic field from the oscillating electric field will not cause severe problems for measurements. The value Dj can be measured if to apply first Ramsey pulse as electric and second − as magnetic (or vice versa), but here we should take into account that the real phase difference (relative to precession) is determined by the product sign(**dn**)**.**Dj. The difference of phases between electric and magnetic pulses when resonance is observed will determine sign(**dn**)**.**Dj, i.e. the orientation of **dn** in the plane of rotation. Probably this technique will have higher sensitivity for EDM measurement than by using only electric pulse.

Conclusion.

- When the magnetic moment of neutron **mn** precesses around the field B the only possible direction of EDM which can be specified is that **dn** is rotating in the plane of precession with w=wp and a phase difference between rotation and precession Dj=±p/2.
- If EDM is not zero it should be possible in this case to cause a spin flip by the oscillating electric field **E=E0**sin(wt) applied in the plane perpendicular to **B**. At w=wp one should observe a resonance similar to the one of Neutron Magnetic Resonance technique.
- The orientation of **dn** relative to the precession can be determined by using Ramsey separated oscillatory field technique only one pulse should be electric and second pulse **−** magnetic. The difference of phases between these two pulses will determine sign(**dn**)**.**Dj.
- For EDM of neutron the range from 10−25 *e*cm to 10−19 *e*cm can not be considered so far as the excluded range.

1)However the correct analyses of this case may reveal some interference of this electric field with precession, what can produce a minor shift of w*p* as a simulation of EDM oriented parallel/antiparallel to **B**. Then it could be the explanation why both experiments [1, 12] obtained the negative values for **d n** (within 3 standard deviations they have null result what implies an upper limit of 12× 10−26 *e*cm at the 95% confidence level).

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[IMAGE] [IMAGE]