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QED theory of light muonic atoms

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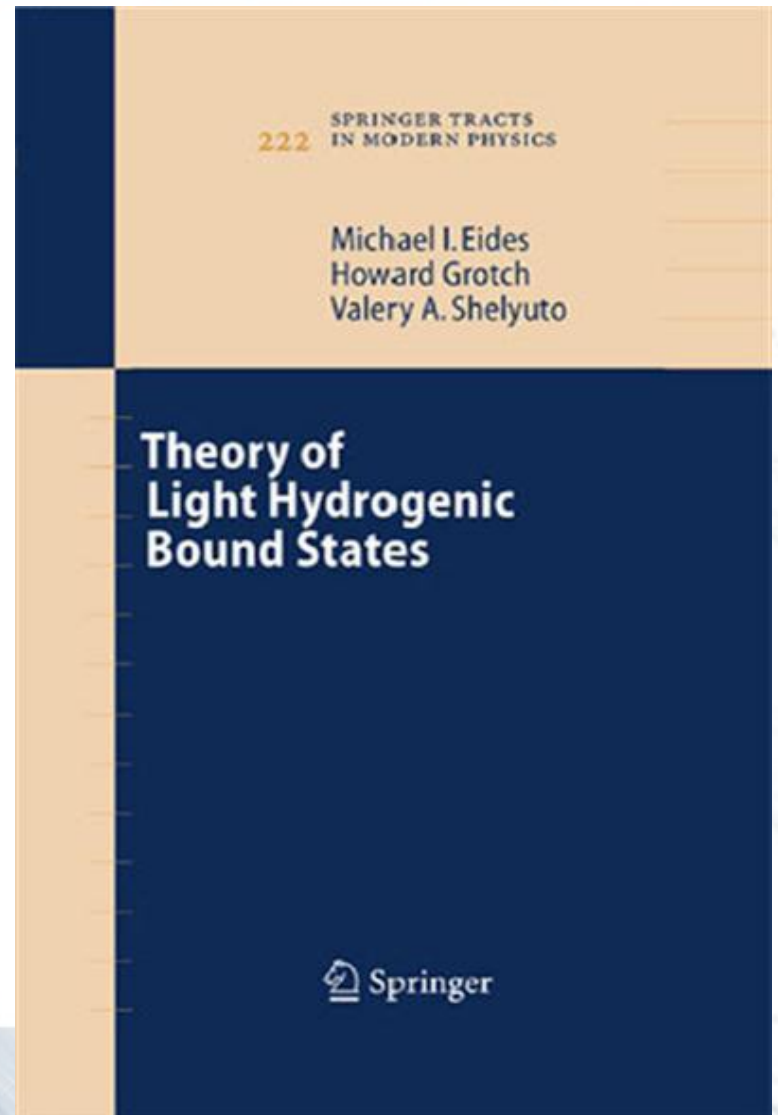
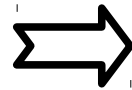
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QED theory of light muonic atoms

QED theory of light muonic isotopes of H and He are well established except of few corrections such as **light-by-light**, **relativistic-recoil** and **VP3**.

The main recipes can be found in



QED theory of light muonic atoms

Recently QED theory for muonic ions of lithium, beryllium and boron was published

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Lamb shift in muonic ions of lithium, beryllium and boron

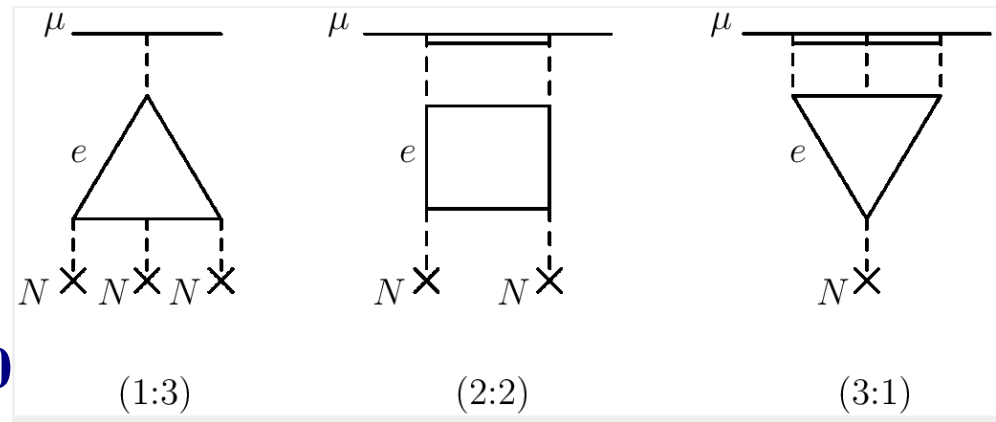
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Now we are calculating light-by-light, relativistic-recoil and VP3 for these muonic atoms. This talk is about LbL

QED theory of light muonic atoms

Light-by-light contributions:



The first calculation was done in 2010

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Nonrelativistic contributions of order $\alpha^5 m_\mu c^2$ to the Lamb shift in muonic hydrogen and deuterium, and in the muonic helium ion

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Contribution of Light-by-Light Scattering to Energy Levels of Light Muonic Atoms[†]

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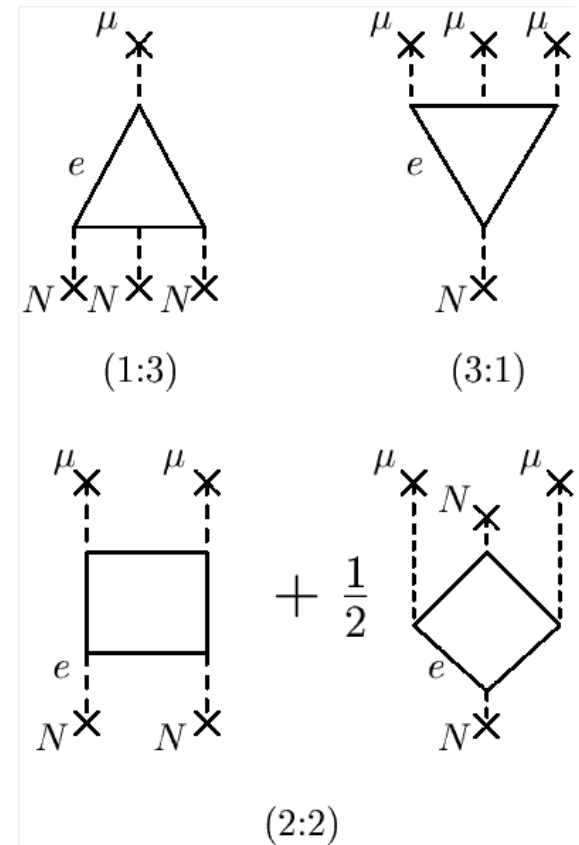
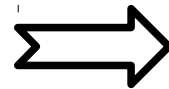
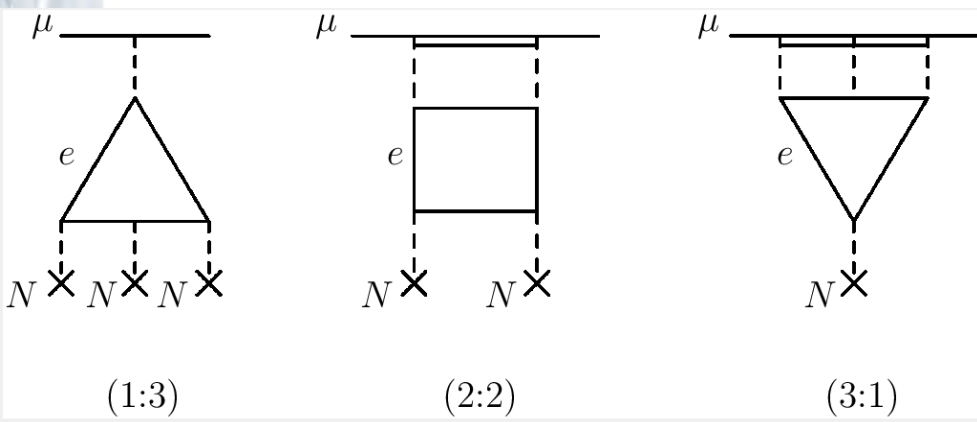
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QED theory of light muonic atoms

Light-by-light contributions:

The main idea



With well controlled uncertainty

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Light-by-light contributions:

The result has a form

$$E = \int dq dq' \Psi(q) V(q - q') \Psi(q')$$

where $V(q)$ was studied and tabulated

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Light-by-light contributions:

	$(\mu\text{Li})^{2+}$	$(\mu\text{Be})^{3+}$	$(\mu\text{B})^{4+}$
LbL [meV]	-0.063(4)	-0.178(15)	-0.38(4)

Таблица 1: Light bi light contribution for muonic ions in meV

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Thank you for your attention!

QED theory of light muonic atoms

Table 3. Contribution of the light-by-light scattering effects (Fig. 1) to the Lamb shift ($2p-2s$) in muonic hydrogen, deuterium and helium-4 ion in MeV

Term	$\Delta E(\mu\text{H})$	$\Delta E(\mu\text{D})$	$\Delta E(\mu^4\text{He})$
1:3	-0.001018(4)	-0.001098(4)	-0.01995(6)
2:2	0.00115(1)	0.00124(1)	0.0114(4)
3:1	-0.00102(1)	-0.00110(1)	-0.0050(2)
Total	-0.00089(2)	-0.00096(2)	-0.0136(6)