When Photons Self-Organize: Making Matter from Light

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In this talk I will discuss ongoing efforts at UChicago to explore matter made of light. I will begin with a broad introduction to the challenges associated with making matter from photons focusing specifically on (1) how to trap photons and imbue them with synthetic mass and charge (2) how to induce photons to collide with one another and (3) how to drive photons to order by cooling or otherwise. I will then provide as examples two state-of-the-art-photonic quantum matter platforms: microwave photons coupled to superconducting resonators and transmon qubits and optical photons trapped in multimode optical cavities and made to interact through Rydberg-dressing. In each case I will describe a synthetic material created in that platform: a Mott insulator of microwave photons stabilized by coupling to an engineered non-Markovian reservoir and a Laughlin molecule of optical photons prepared by scattering photons through the optical cavity. I will conclude with an outlook on new experimental platforms we are developing to marry these techniques and ideas!