Pigments and Lumens

Technical Summary - July 2019

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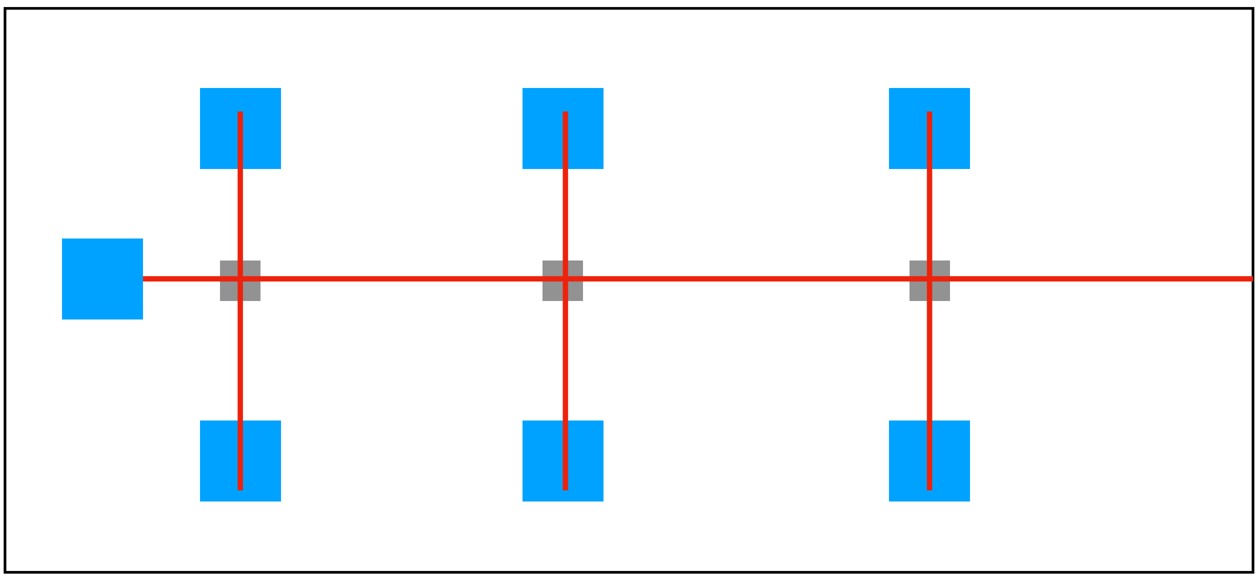
Motivation
For centuries, we have thought about architectural lighting in the same way. If you want to illuminate a volume you add more fixtures in certain areas of a room and based off the light bulb's properties you achieve various illuminations. Recent inventions such as LED and smart light bulbs have sought to save energy and reduce the carbon footprint of architectural lighting, but there is still more work to be done in the infrastructure, maintenance, and flexibility.

Framework
Our framework imagines a new type of light bulb — where one source of light can illuminate multiple bulbs in the same room. We primarily propose to do so with a laser and multiple resin "bulbs", such that we can arrange a laser in a ceiling and utilize geometry of beam splitters and mirrors to take its light throughout the room.

Fig 2: Framework diagram — red is laser, blue is resin cubes, and grey boxes are standard cube beam splitters. This could be a ceiling schematic with the laser contained in the wall and being mirrored into the setup or with the laser mounted to the ceiling. Other and more complex geometries can be created with mirrors and beam splitter combinations. (Conceptual only — not to scale)



This completely changes how lighting can be done in any space, especially in the following factors.

Infrastructure
The infrastructure of this method requires less material and different lighting geometries. Instead of electrical wiring and sources throughout a whole ceiling, only a few points of source need to be wired, thus introducing less between floor and ceiling complexity of wiring for lighting in large or complex spaces.

Maintenance
Because there is only one (or only a few for a very large, complex space) points of electricity, there are fewer points of maintenance in the event of a system restart or repair. Furthermore, the idea of taking the electrical wiring out of the ceiling and simply projecting the source upwards from a more reachable location on a wall.

Flexibility
Because we need less light sources and are not restricted by ceiling wiring, this can accommodate a variety of complex spaces at scale — from unique curves and silos to larger structures that are difficult to traditionally illuminate. Furthermore, lighter infrastructure can apply itself to temporary structures as well.

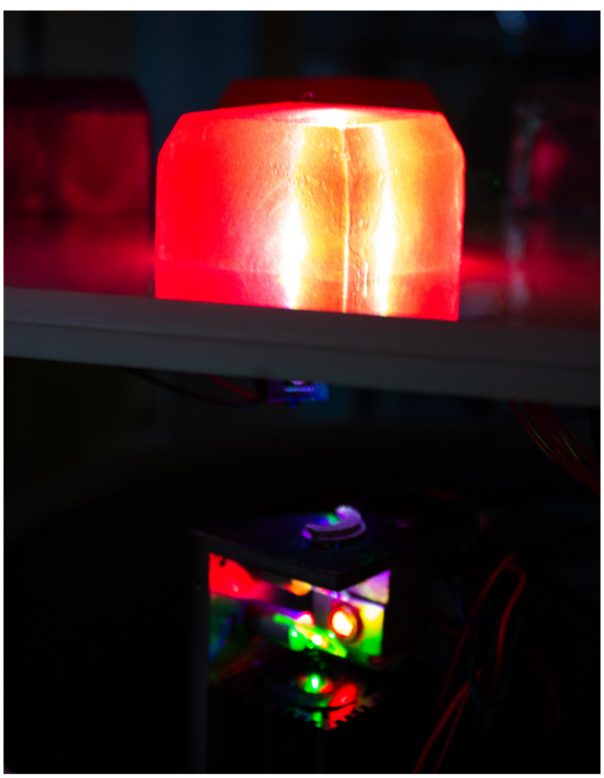
Methods and Concept
The concept behind this framework is to introduce a new paradigm to architectural lighting. Instead of individual fixtures, we can use one coherent light source to illuminate multiple.The method exploits 2 functions of light — light rays and colloidal scattering.

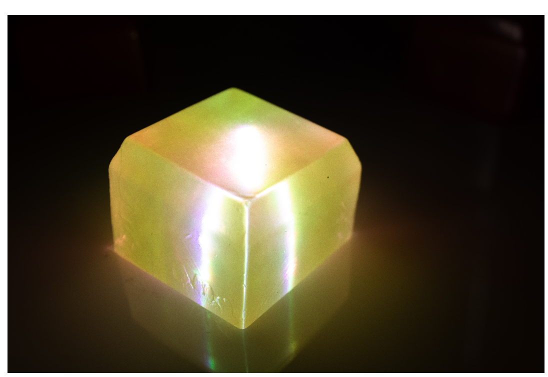
Light rays are how light travels — infinitely in a predictable path until interrupted. Lasers are a powerful, concentrated example of a diode that has been concentrated to a singular, bright point of light that will go on infinitely until stopped. Lasers are bright and unobtrusive — you do not see the beam until they are diffused.
Possible sources:
- Laser diodes
- Bright projectors
- Some high powered LEDs and spotlights

Colloidal scattering and diffusion is the complexity of our method. The best way to consider this is the question of fog. If you are driving through fog you are not supposed to put on your high beams, because the light reflects back and becomes too bright to see. Fog is a colloid, a particle system that has various properties that cause light to be reflected and scattered in an amplifying matter.

Our current implementation of combing these are using resin "bulbs" and a white laser, as seen below with a singular resin and laser set up in our lab space.

Fig 2: Singular fixtures with a white laser setup. Fig 4 and 5 show additional resins and lasers and Fig 6 and 7 show different laser geometries from the resin.





These bulbs are made of pigments and polyester resin. These can be any color or finish. The typical medium we are using at the moment is loose eyeshadow pigments due to their predictable formulation and customizability in color and glitter effects.

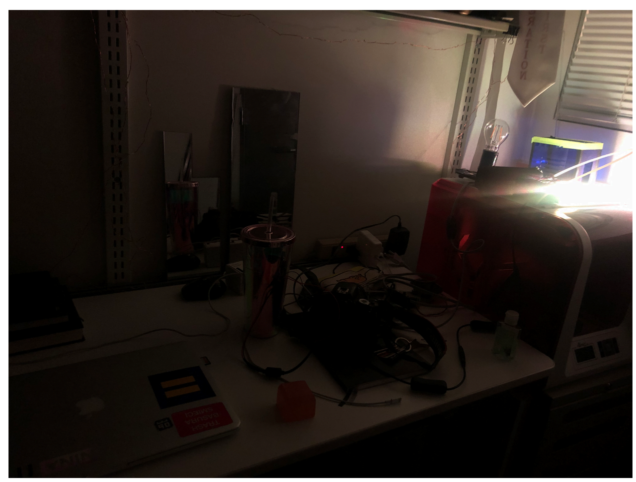
We can fine tune the bulbs to be a variety of different, predictable light intensities. We can therefore compare a particular resin to a traditional light bulb equivalent for architectural modeling and light planning purposes. Utilizing two different mathematical models we can reliably predict and manufacture these fixtures in virtually any shape or color.

Colloidal Distribution Model
This model allows us to configure the amount of resin, pigments, and chemical catalyst based off the shape of the mold and desired density of the pigments.

Lumen and Colorspace Model
Based on the pigments used, density of them, and shape of the resin, this allows us to predict the color space of the light that the resin will emit when under different illumination as well as the lumen and wattage equivalent of a traditional light fixture.

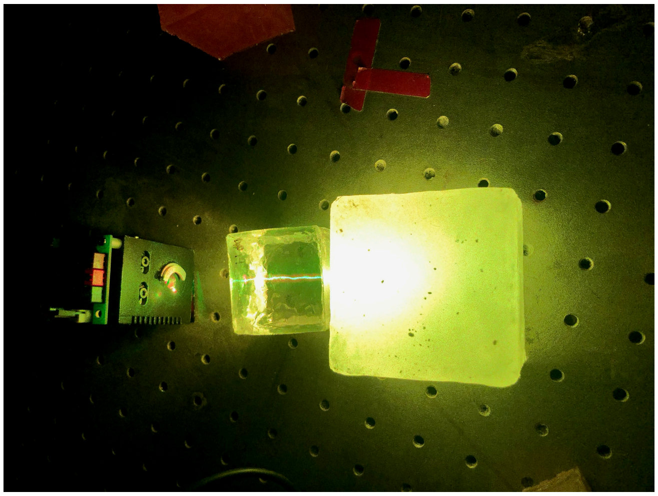
And even with one 2" x 2" x 2" cube resin, we can get comparable lighting to a traditional light bulb, as seen below.

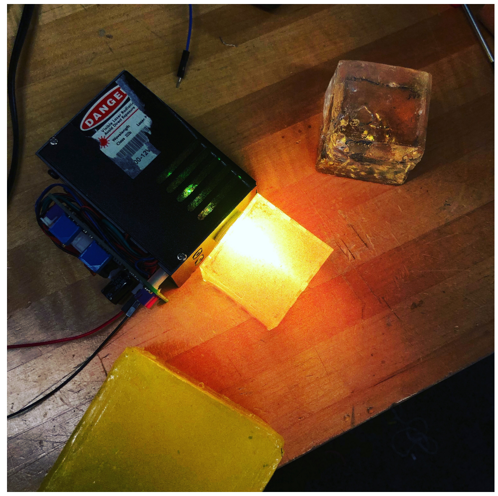
Fig 3: Traditional light bulb and singular 2" x 2" x 2" resin light illuminating a space. Photos on iPhone 8, unedited. Light bulb is 70 watt.



Because we use an RGB white laser, we can illuminate the resins in a variety of colors, as seen below with resins illuminated with our laser tuned to yellow.

Fig 4: Singular fixture with a yellow laser





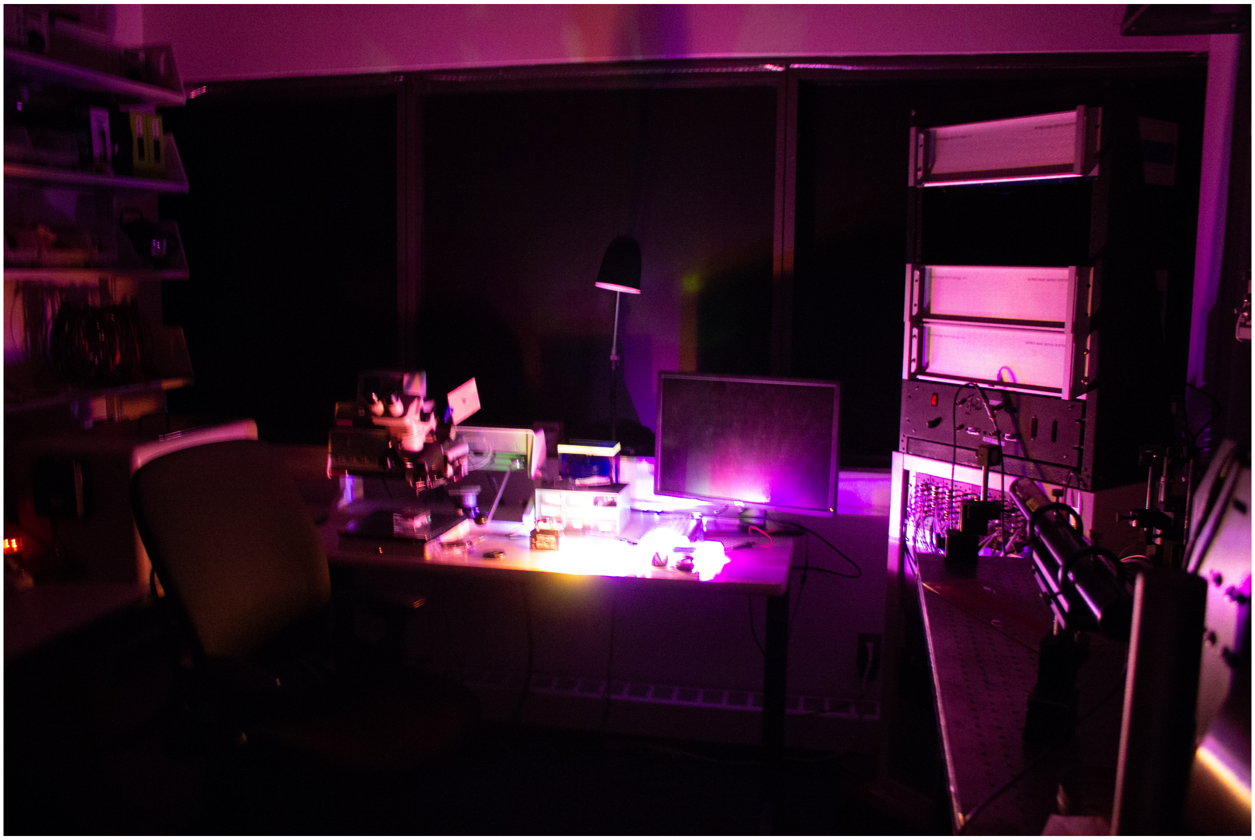
The resins themselves can provide illumination in a variety of colors and textures that create a truly beautiful and mesmerizing experience for lighting.

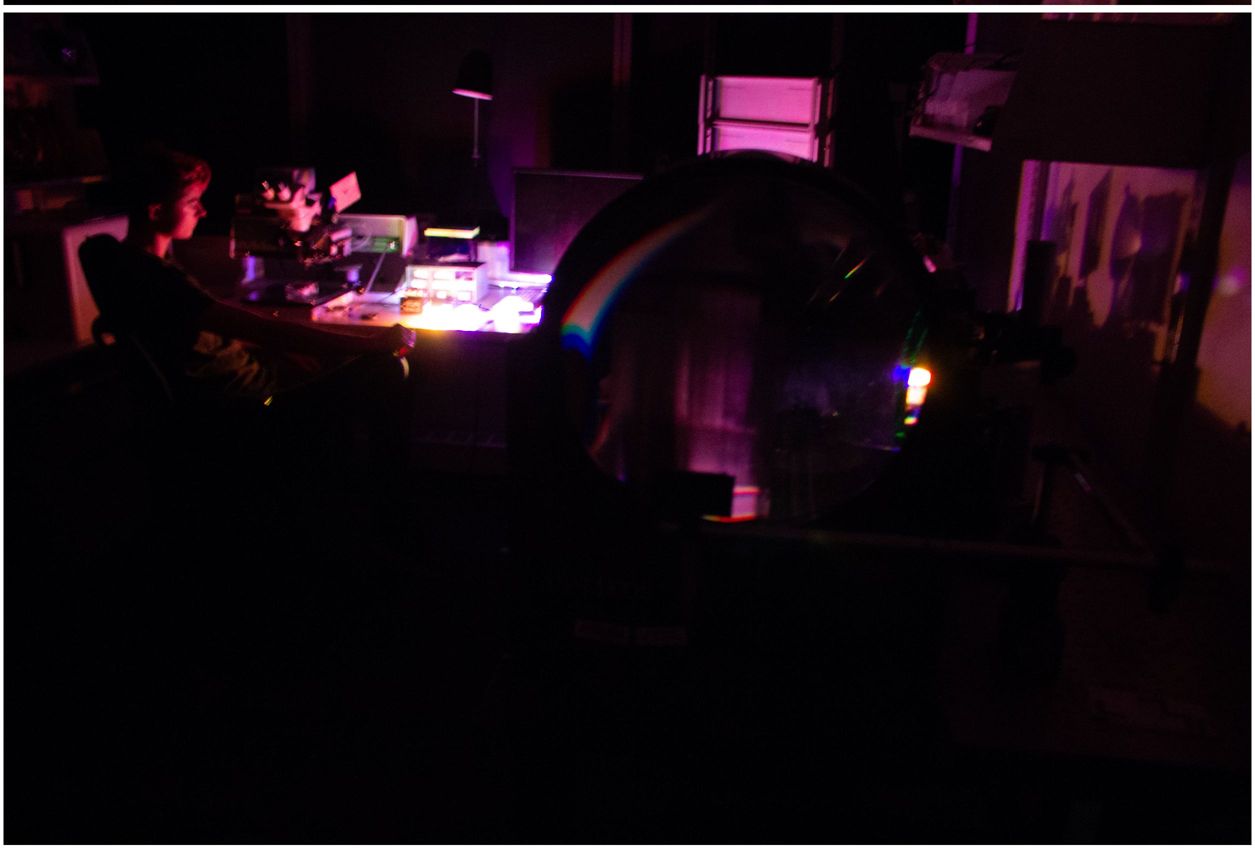
Fig 5: Additional resins

But we also have the ability to use beam splitters to illuminate multiple resins at once, as seen in Fig 6. As well as illuminate resins from very far from the laser, as seen in Fig 7.

Fig 6: Multiple resins illuminated by a singular source

Fig 7: Resins at a room scale and far away. The following images were in a completely dark optics room only illuminated by the laser and resins above.





Applications and Future Work
We hope to apply this method to a variety of architectural spaces and case studies and are eager to expand and experiment in new ways.

Because resin casting is a controlled and regulated fabrication

We look forward to these case studies along with patenting and publishing our mathematical models

Additional Documentation and information
Some additional documentation can be found here, including a video: https://www.media.mit.edu/projects/pigmented-lumens/overview/

Please contact Nina Lutz for particular details (nlutz@mit.edu)