

A Theory of Joint Light and Heat Transport for Lambertian Scenes

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https://imaging.cs.cmu.edu/joint_light_heat_transport/



When Light strikes a surface...

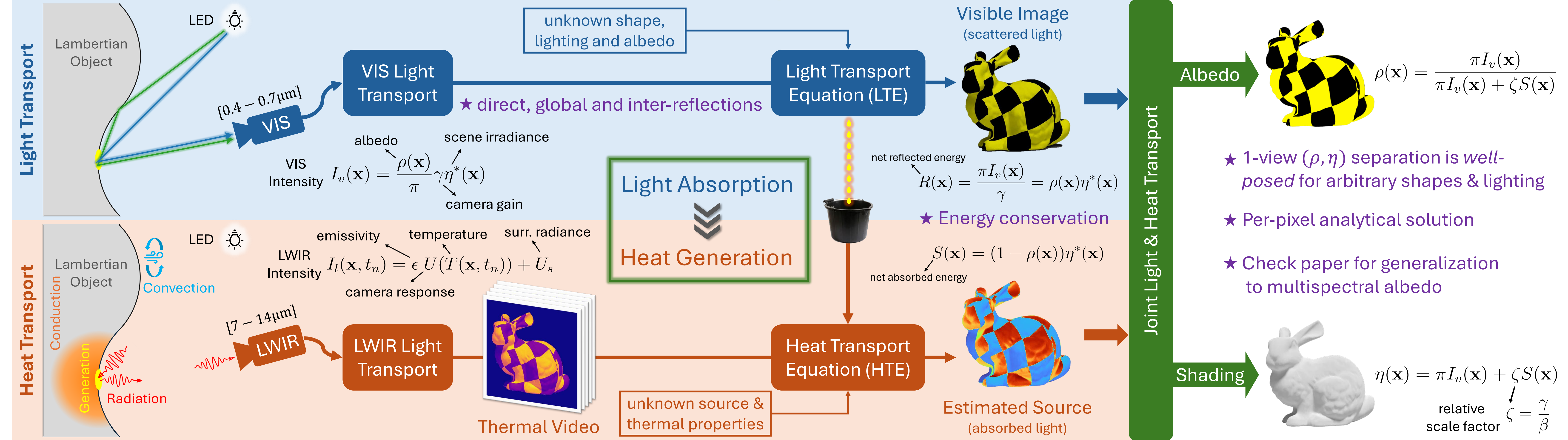


Light lost in **Visible**,
Shines bright in **Thermal**.



Scattered photons stay in Light Transport

Absorbed photons enter Heat Transport



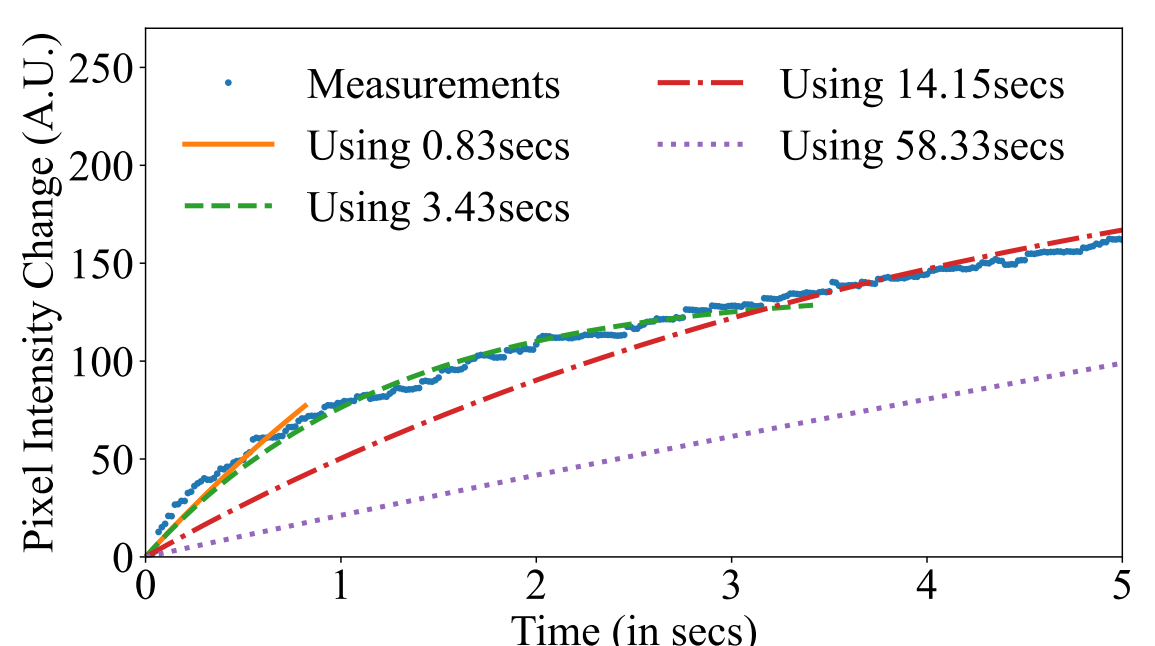
Solving the Heat Transport Equation (HTE)

$$C_v \delta_z \frac{\partial T(\mathbf{x}, t)}{\partial t} = S(\mathbf{x}) + \sigma \epsilon (T_s^4 - T(\mathbf{x}, t)^4) + h_c (T_a - T(\mathbf{x}, t)) + \delta_z (\nabla_x \kappa \cdot \nabla_x T(\mathbf{x}, t))$$

\star independent of λ
 convection coeff. air temp.

Without conduction, the solution to HTE is:

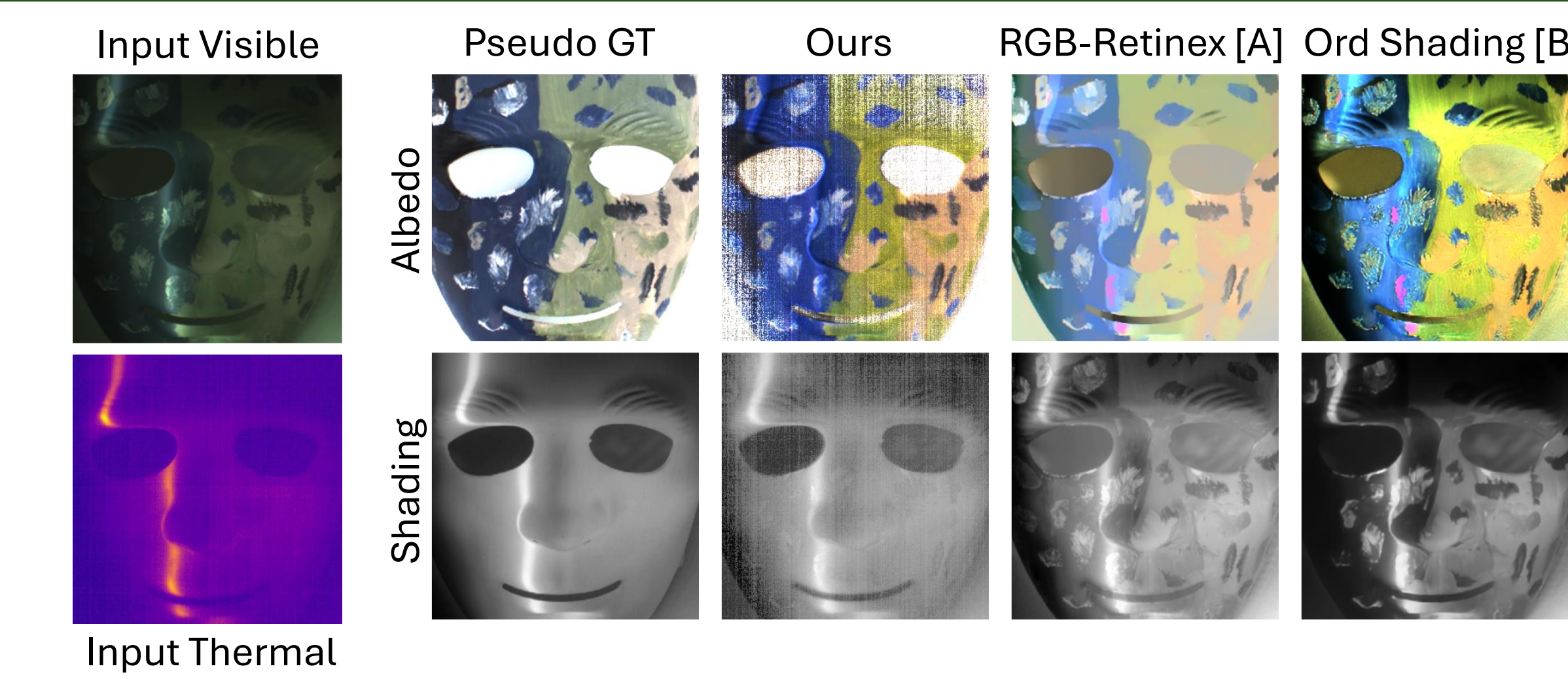
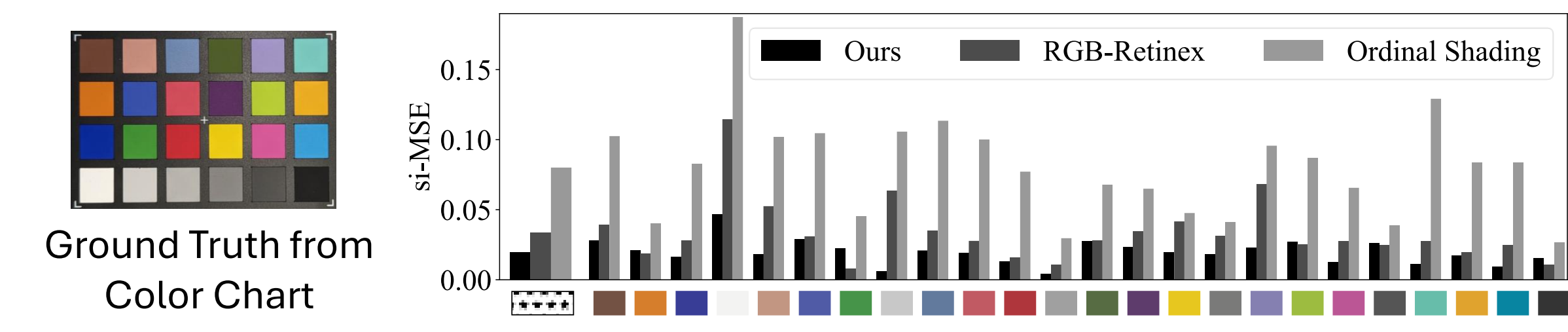
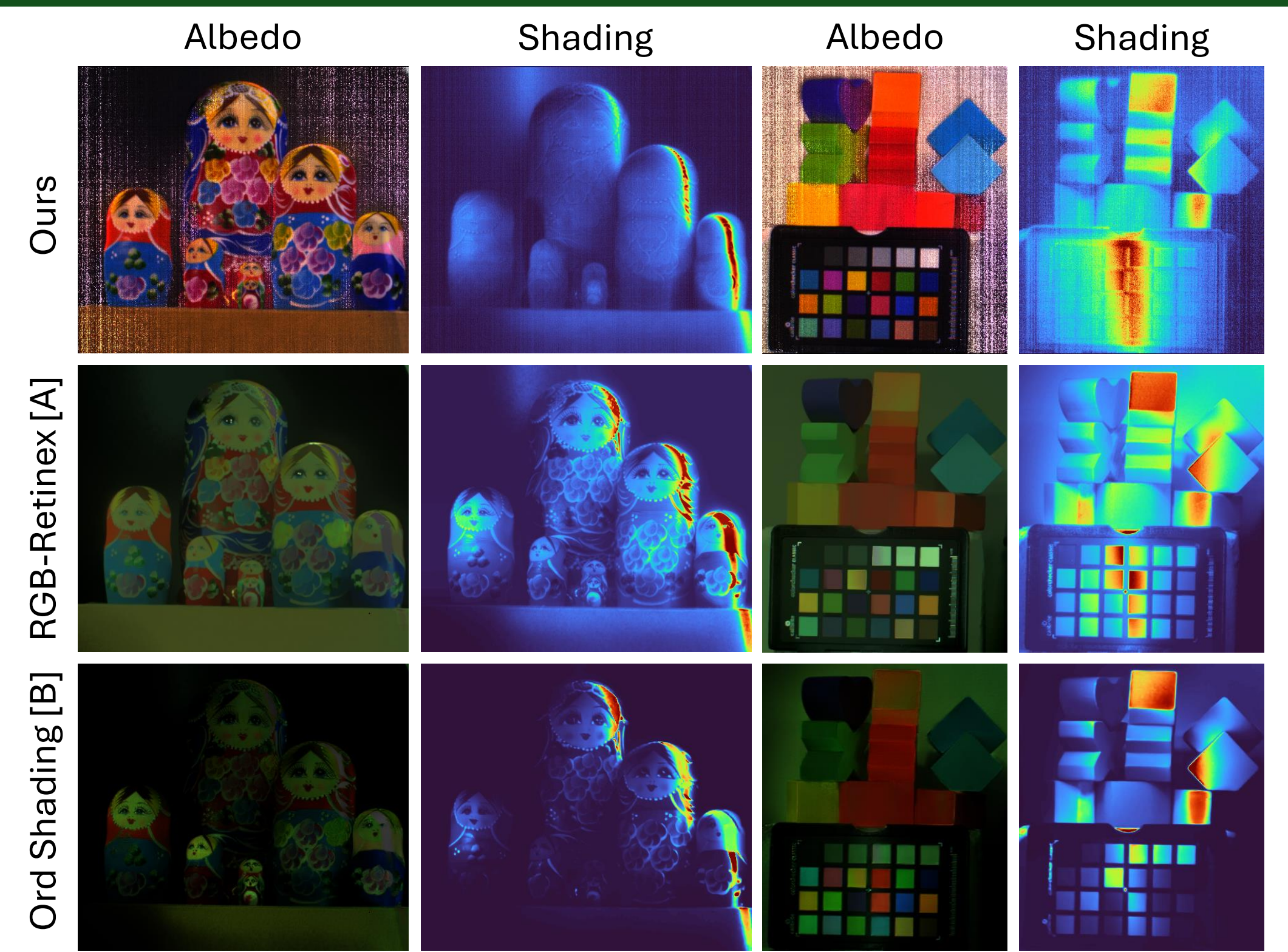
$$I_l(\mathbf{x}, t_n) - I_l(\mathbf{x}, t_1) = \beta S(\mathbf{x}) \left(1 - e^{-\frac{t_n - t_1}{c_2}}\right)$$



Curve fit for various video lengths

\uparrow Video length \uparrow SNR
 \uparrow Conduction \downarrow Fit near t_0

Comparison to SoTA ([A] Grosse et.al.2009 ICCV [B] Careaga & Aksoy 2023 ToG)



How can absorbed light help you?

- ❖ Extending to Non-Lambertian scenes
- ❖ Recovering shape from Heat Transport
- ❖ Measuring material properties
- ❖ High-precision temperature measurements

Limitations

- ❖ Need thermal transients i.e., a video
- ❖ Needs co-located imaging setup
- ❖ Needs constant ambient conditions