unity

Unity技术开放日

UNITY OPEN DAY

高灵活度、低美术成本的水体渲染系统

王骁建
Graphics Programmer @ Unity TA Team

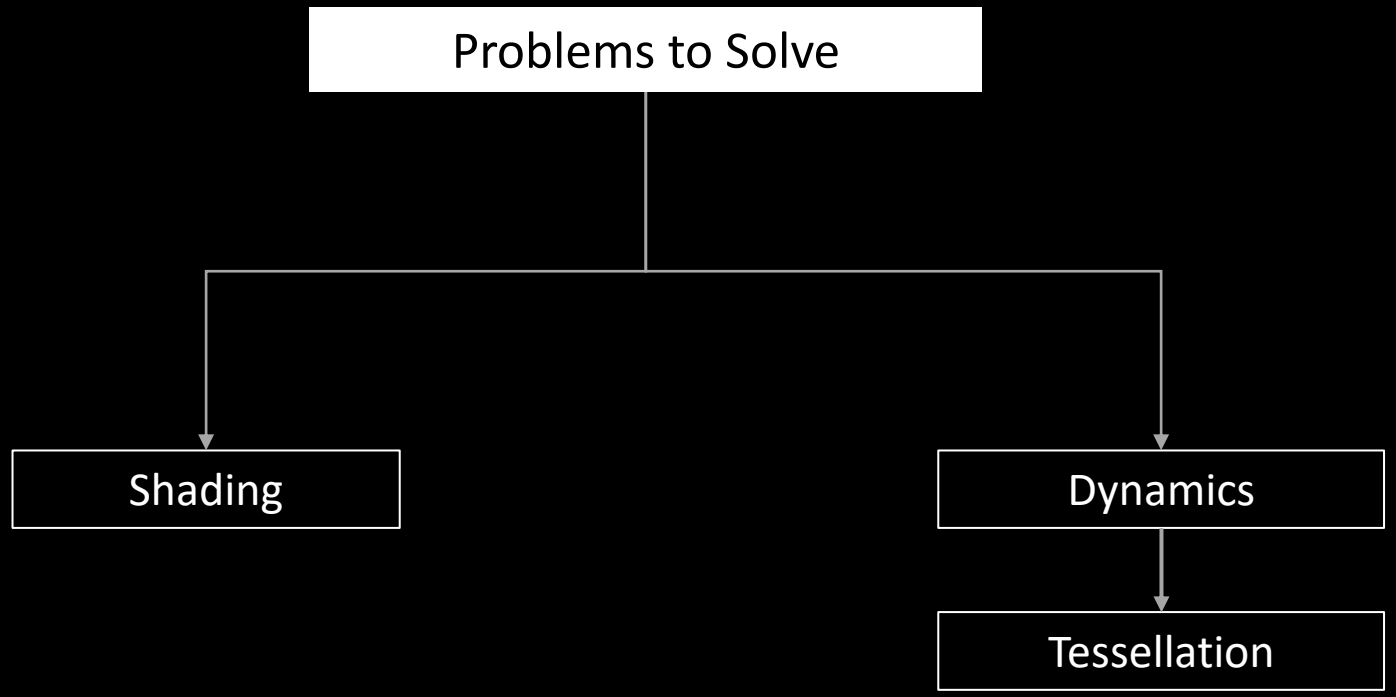
Diverse Appearance

Drastic Motion

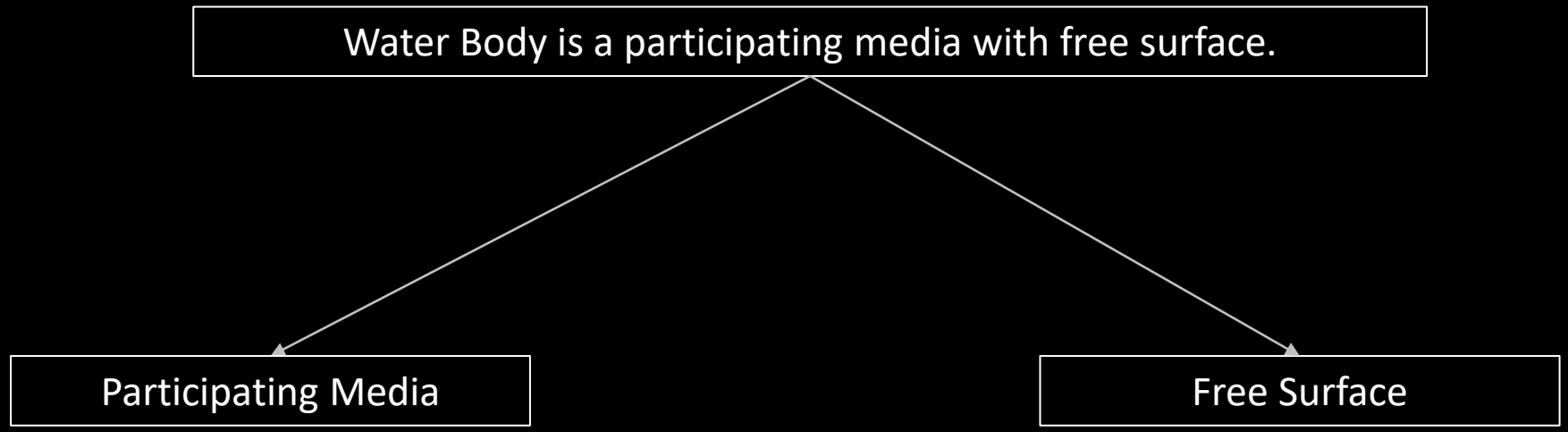
Complex Optical Behavior

Highly Detailed

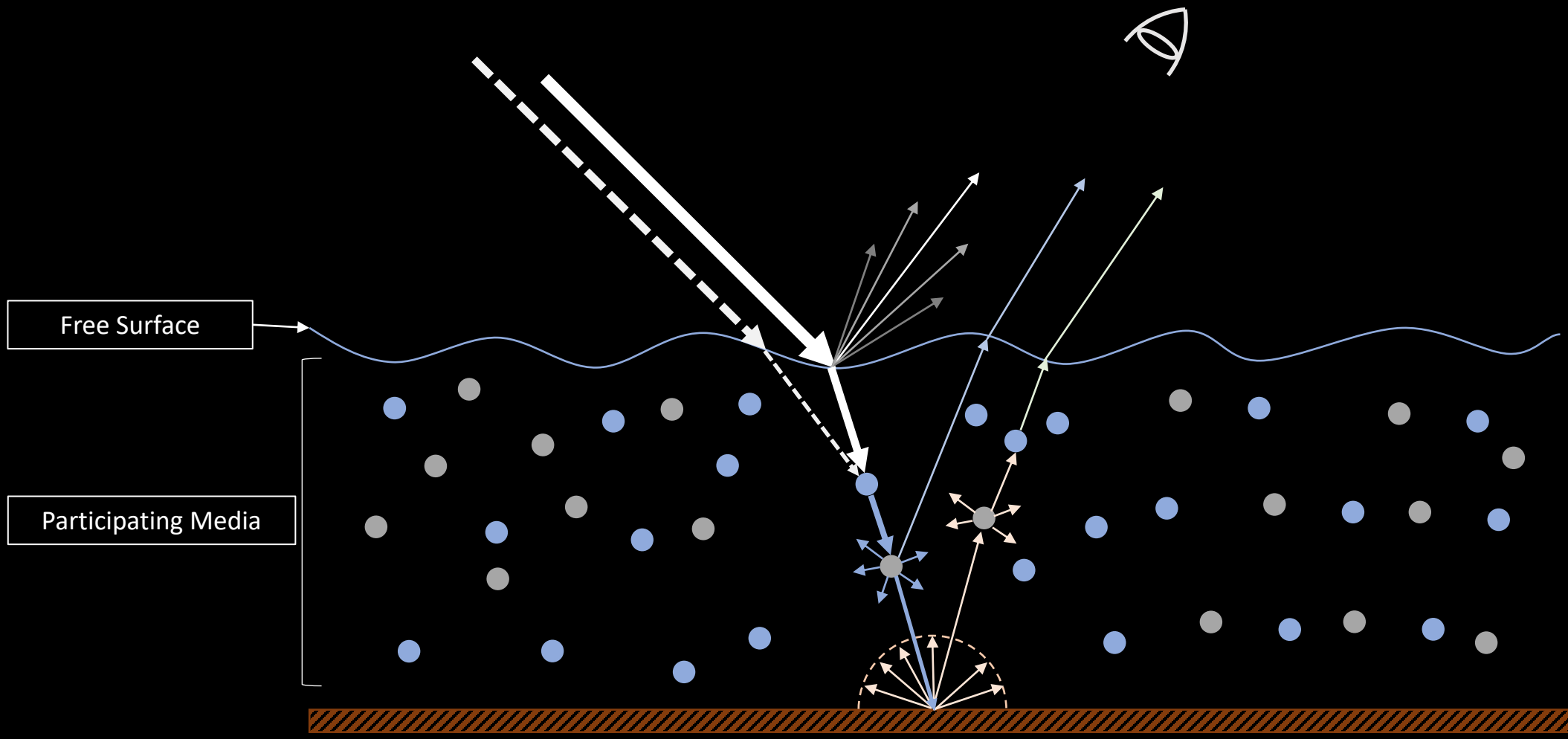
Water Rendering



Shading


Water Body is a participating media with free surface.
Participating Media
Free Surface

Water Lighting Behavior



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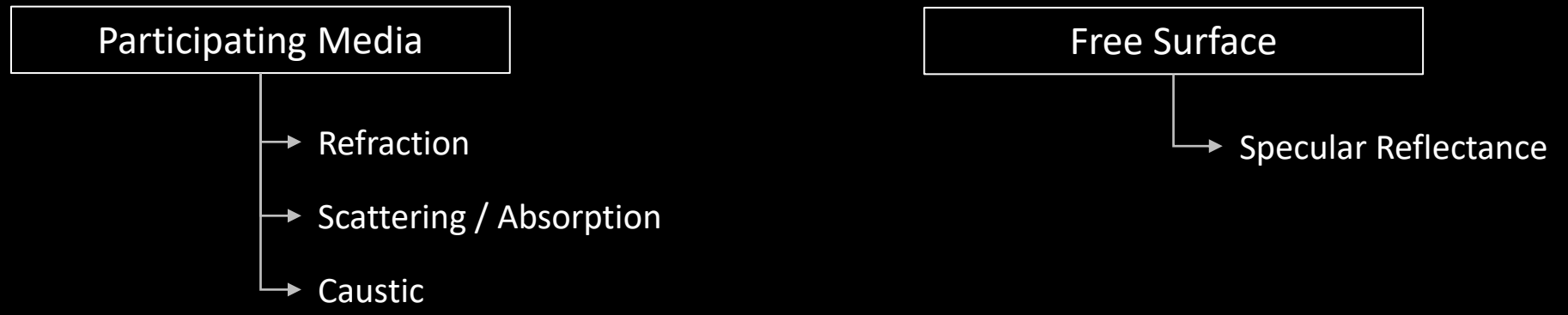
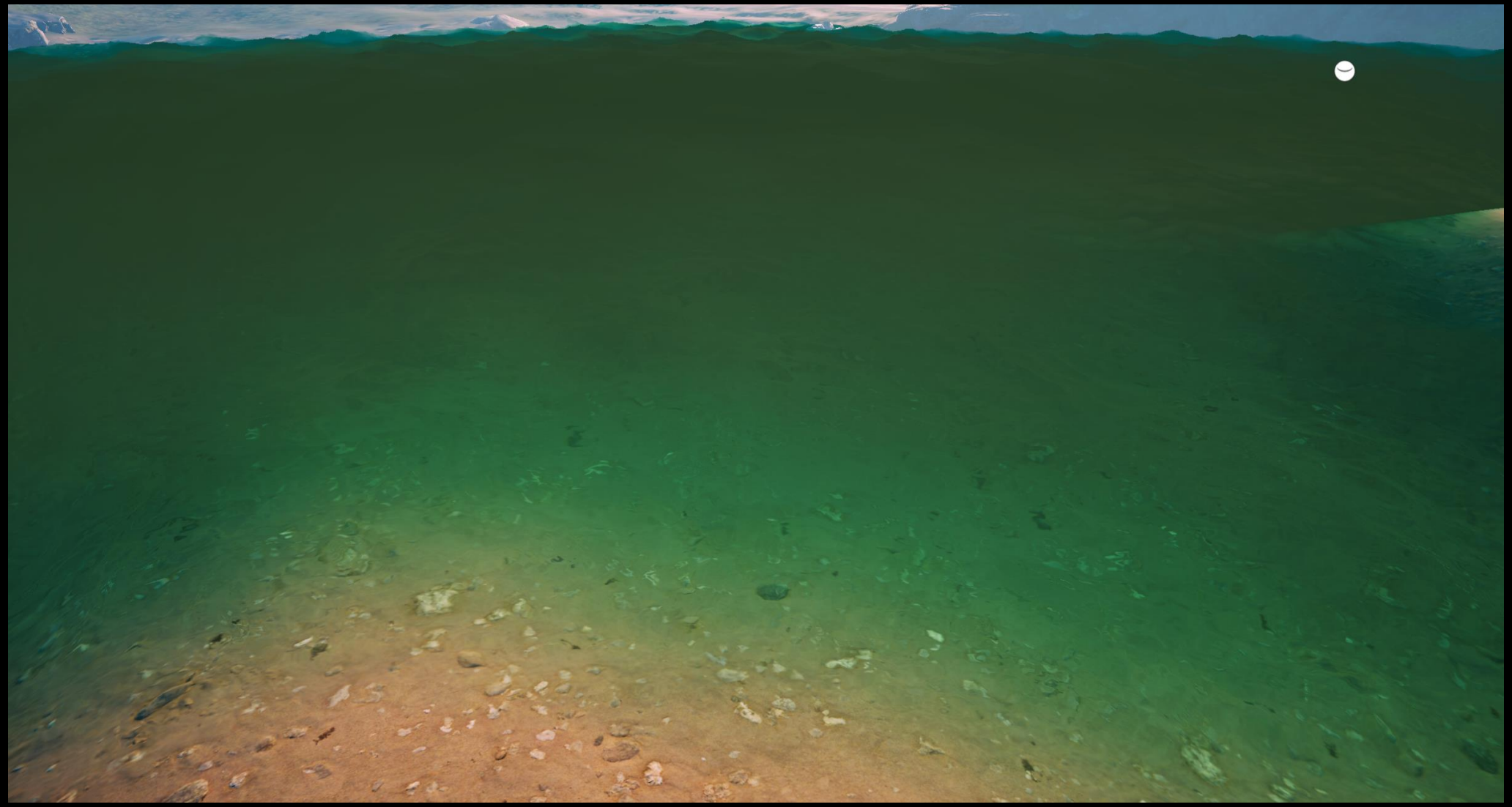

Participating Media
Refraction
Scattering / Absorption
Caustic
Free Surface
Specular Reflectance

Original Scene

Refraction

Absorption

Scattering



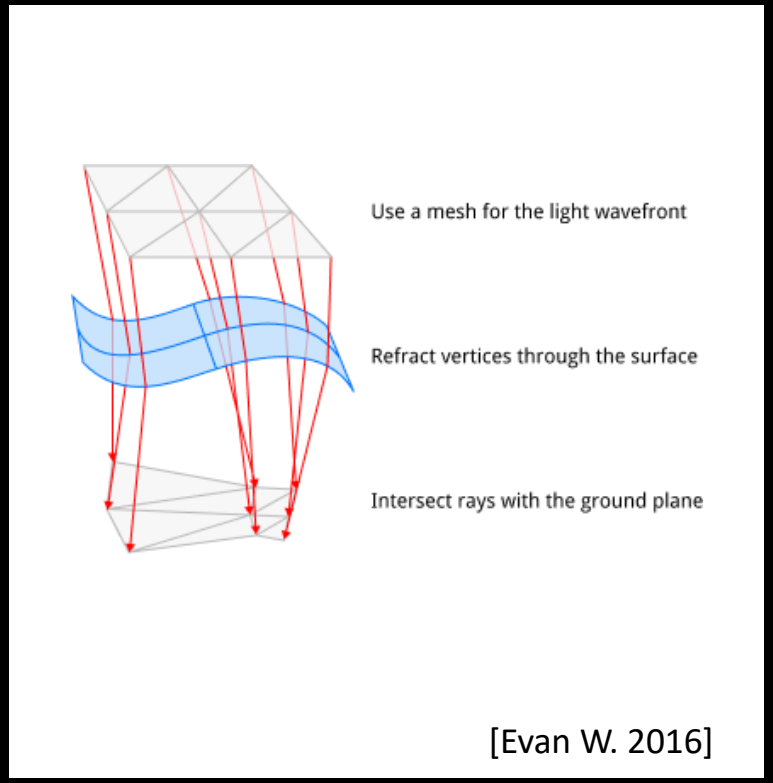
Screen Space Reflection

Reflection Probe

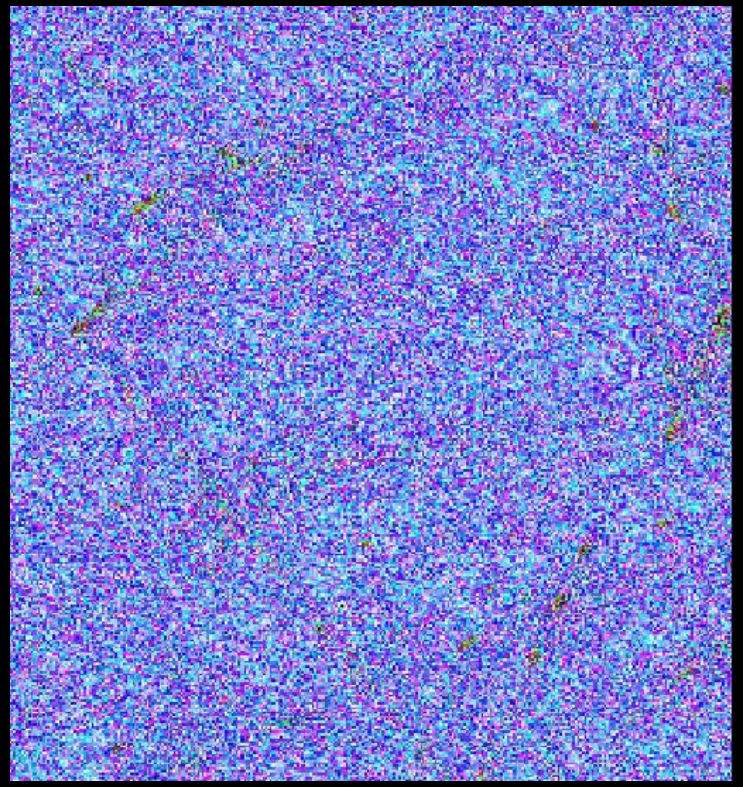
Specular Lighting

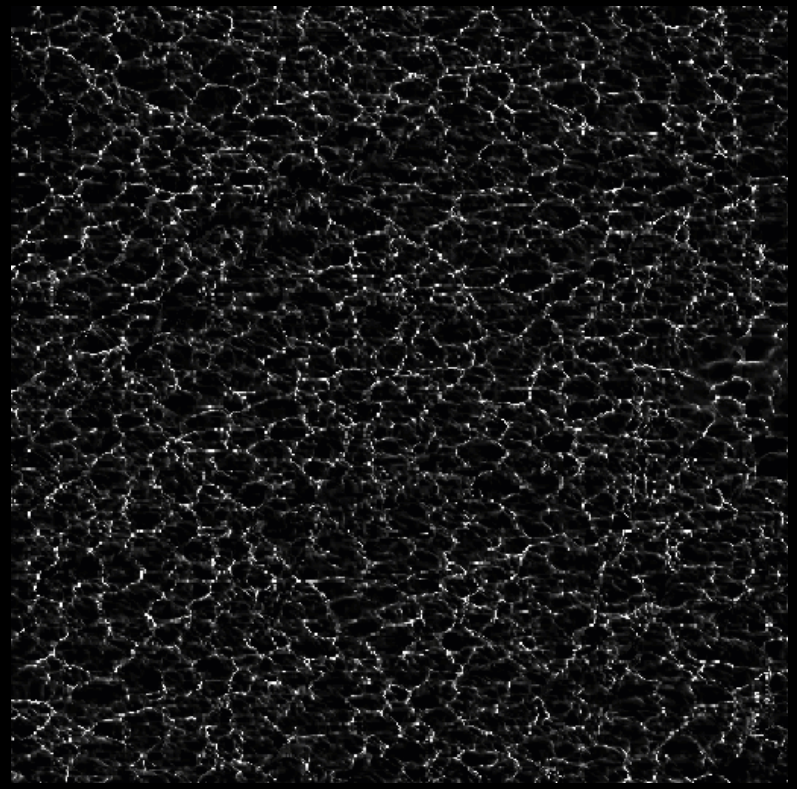
Caustics

Realtime Caustics



[Evan W. 2016]





Shading

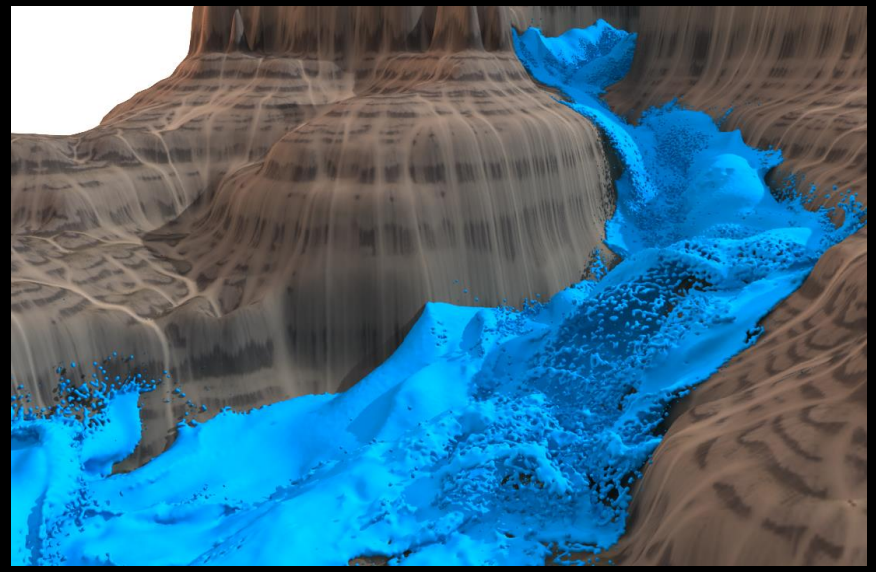
Debris

Foam

Decal

Dynamics

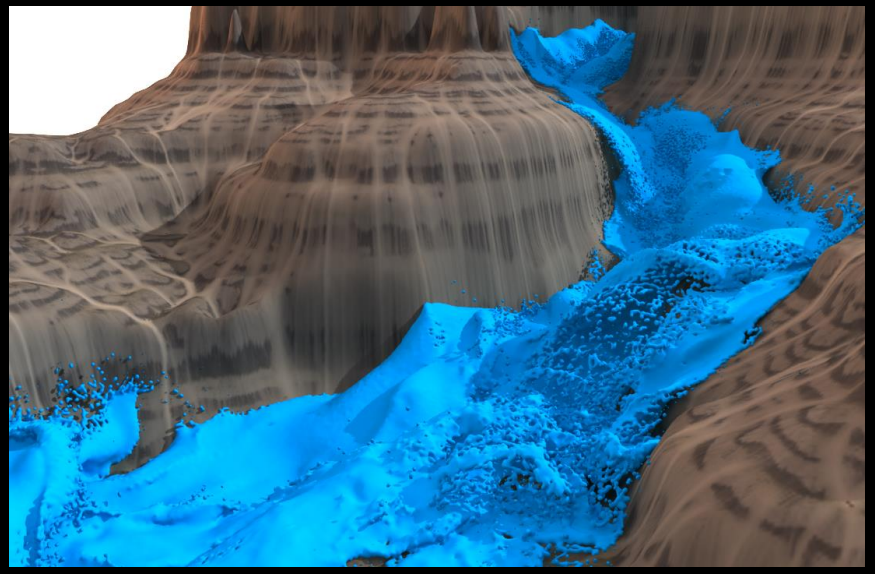
Partial Differential Equation Based



Spectrum Based

Dynamics

Partial Differential Equation Based



Solve the Navier-Strokes Equation
Eularian/Lagrangian

Pros

- Physically Correct
- Rich Appearance
- Fully Dynamic
- ……

Cons

- Too expensive to be real-time

Dynamics

Spectrum Based

Select a group of frequency
Propagate them by some rules

Pros

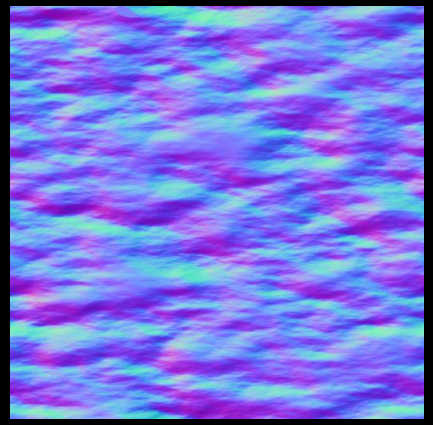
- Faaaaaaaaaaaaaaaaaaast!
- Better artistic control
- Rich appearance also can be achieved

Critical

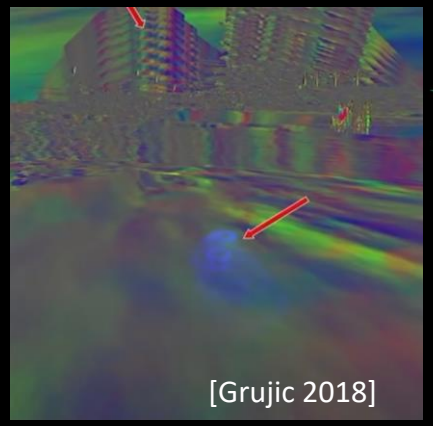
Cons

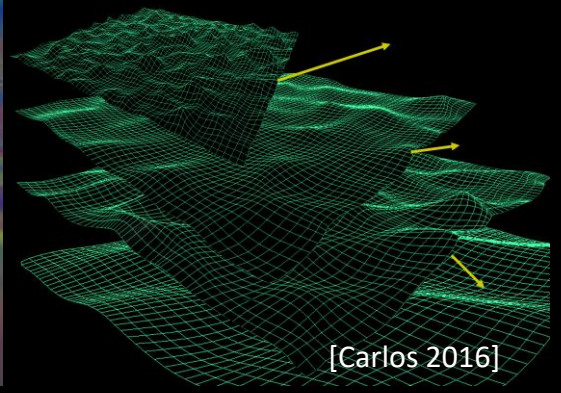
- Static
- Need a lot of artiest’s work

Spectrum Based Water Dynamics

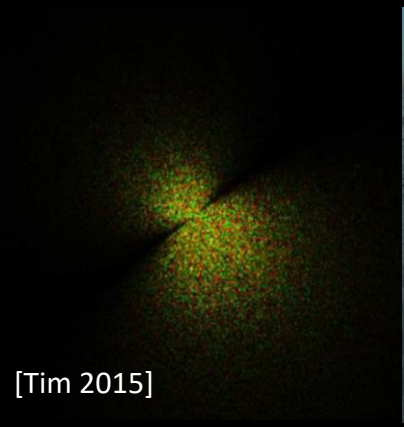


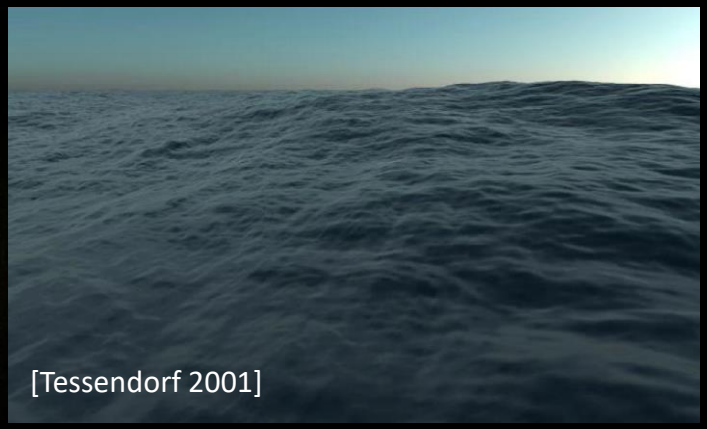
Classic Normal Map



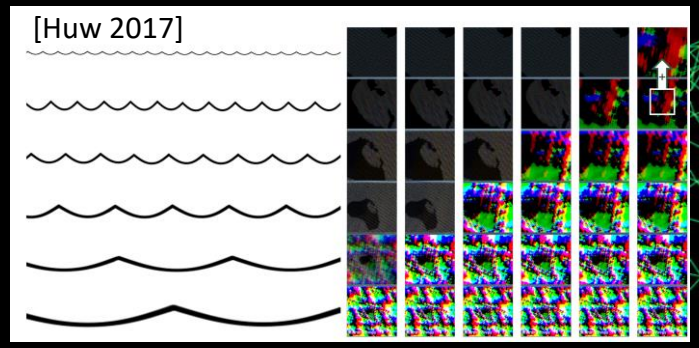


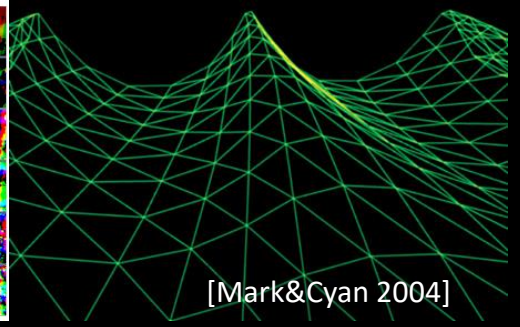
Pre-made Multiple Frequency Displacement





Oceanography Spectrum + iFFT





Trochoidal/Gerstner Wave Composition

Spectrum Based Water Dynamics

Multiple Frequency Gerstner wave for finite water body

FFT for Infinite Ocean

FFT for Infinite Ocean

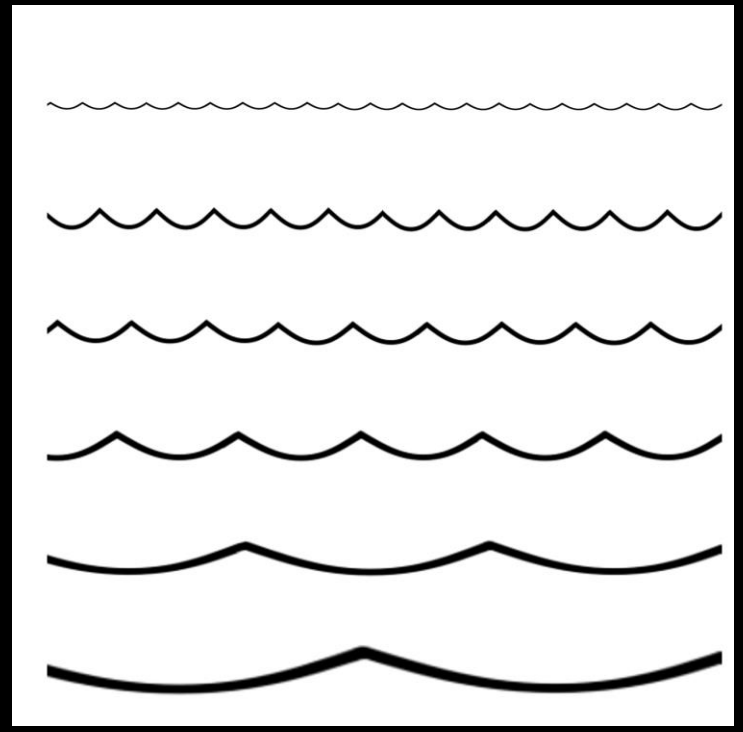
- Wind force driven spectrum
- Cascade approach to avoid tiling artifact
- Highly Detailed

Gerstner Wave Composition

for finite water body

Why?

- Intuitive
- Easy to get same result on both CPU and GPU
- More artistic control
- No texture asset needed for wave displacement



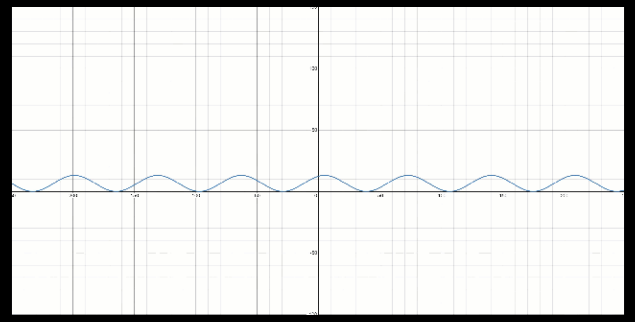
[Huw 2017]

Gerstner Wave

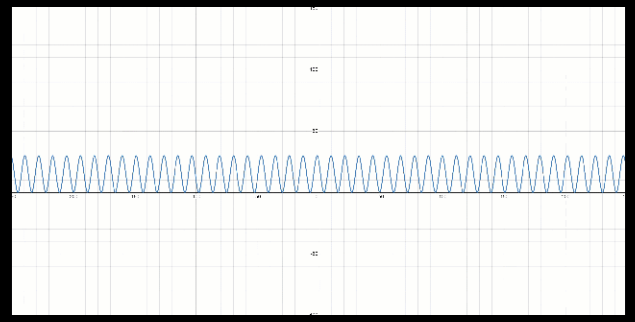
$$y = A\cos\left(\frac{2\pi}{L} \cdot \mathbf{x}_0 - \omega t\right)$$

$$\mathbf{x} = \mathbf{x}_0 + QA\sin\left(\frac{2\pi}{L} \cdot \mathbf{x}_0 - \omega t\right)$$

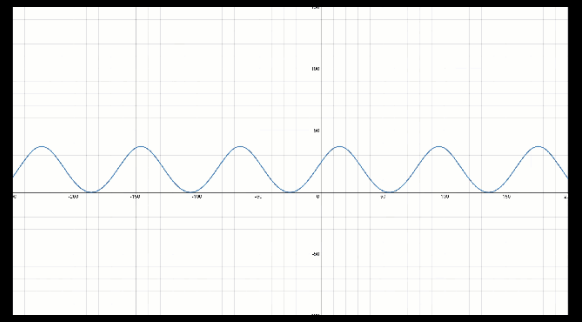
Amplitude



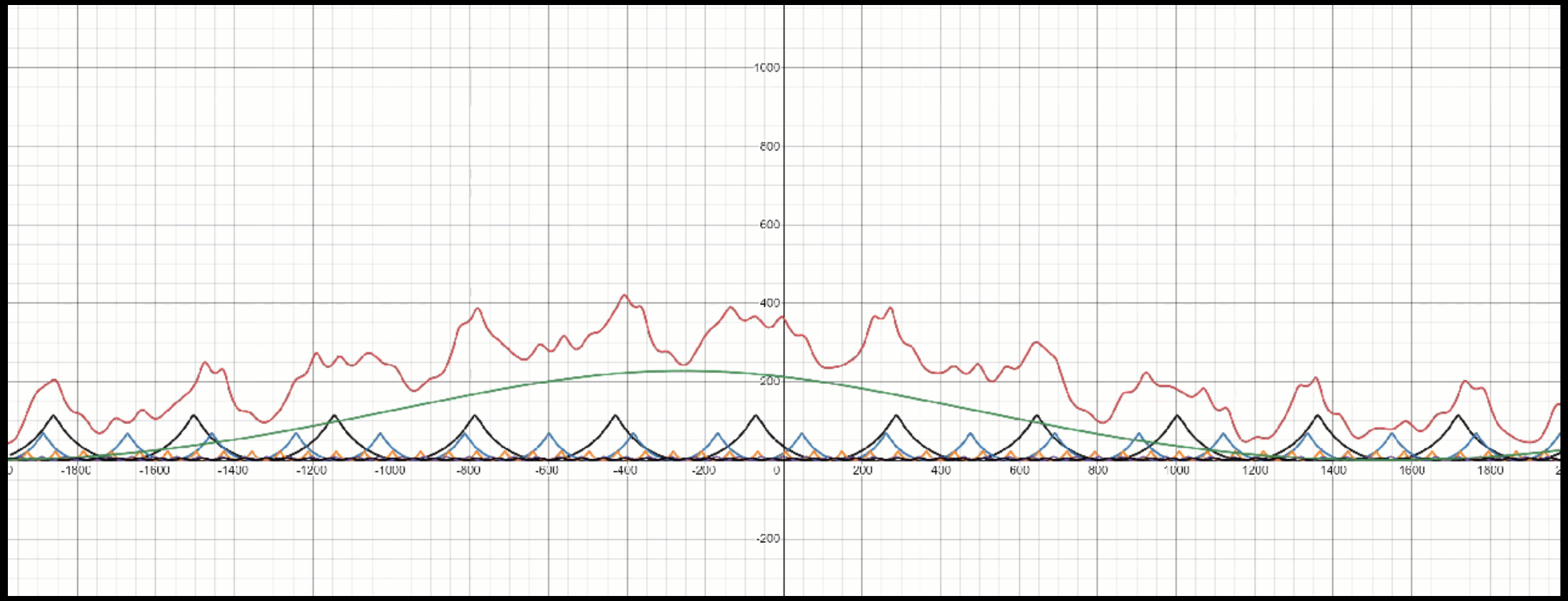
Wavelength



Steepness



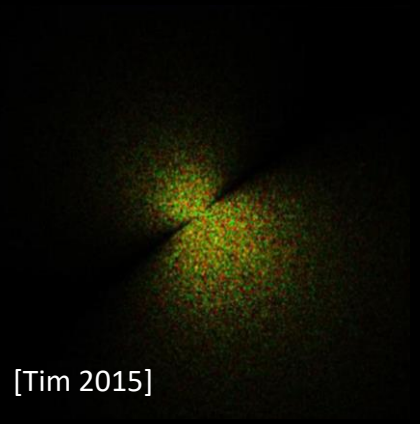
Multi-Frequency Gerstner Wave Composition



6 Gerstner Wave Summation

Multi-Frequency Gerstner Wave Composition

How to extend it to 2D plane ?



[Tim 2015]

[Epic 2020]

Multi-Frequency Gerstner Wave Composition

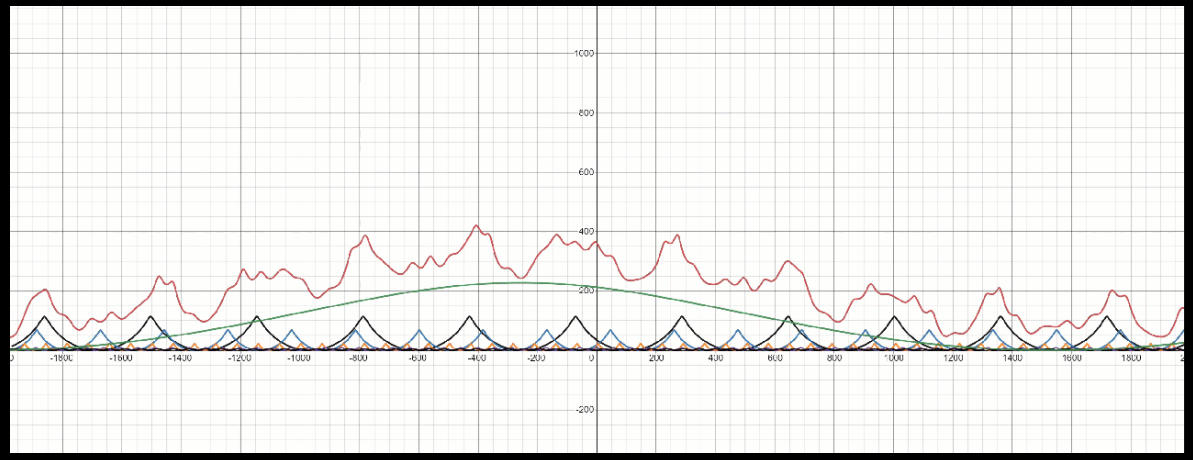
What about rivers ?

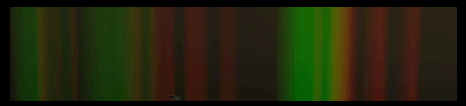
River needs **FLOW MAPS**

Multi-Frequency Gerstner Wave Composition

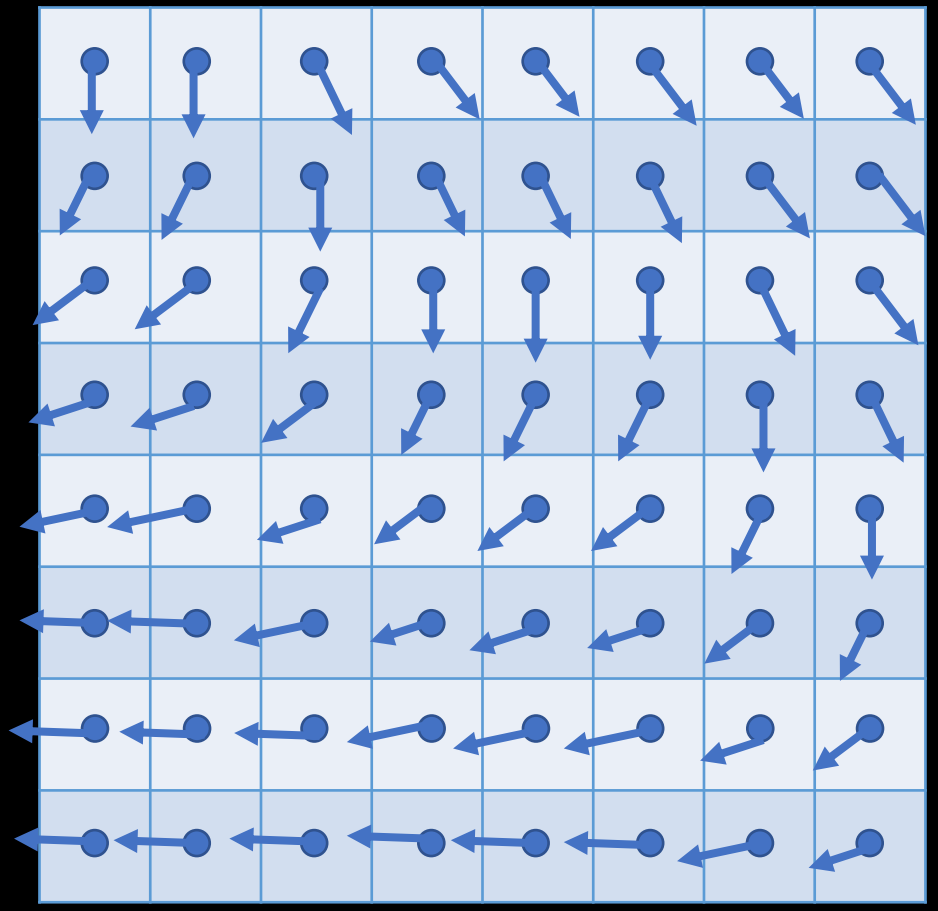
1D Wave Profile + Direction Spreading Function

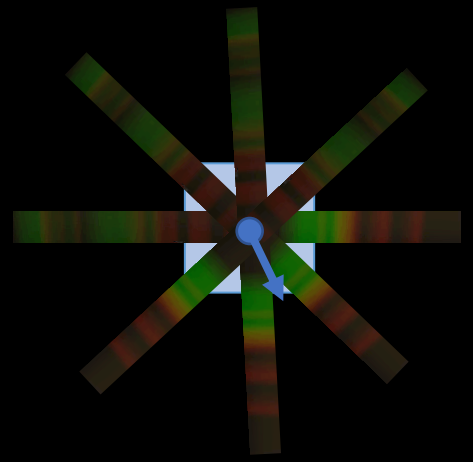
[Stefan J. 2018]





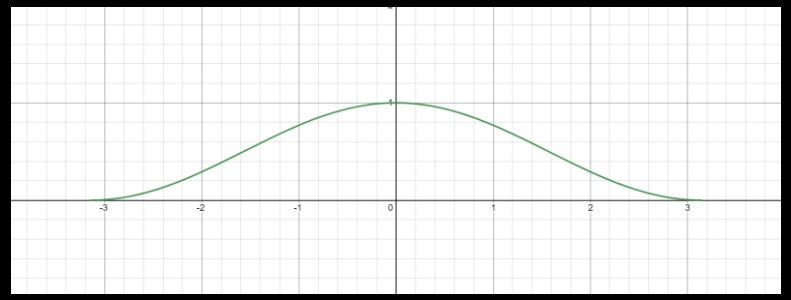
Multi-Frequency Gerstner Wave Composition

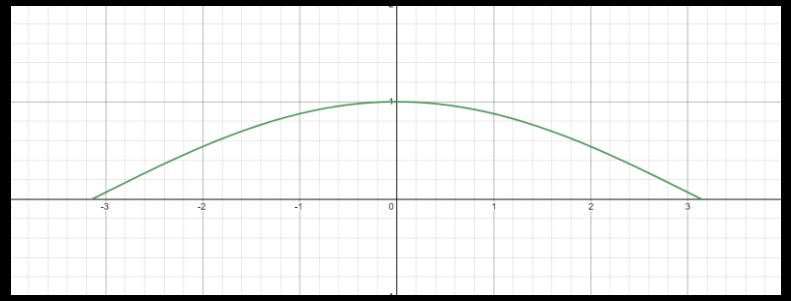


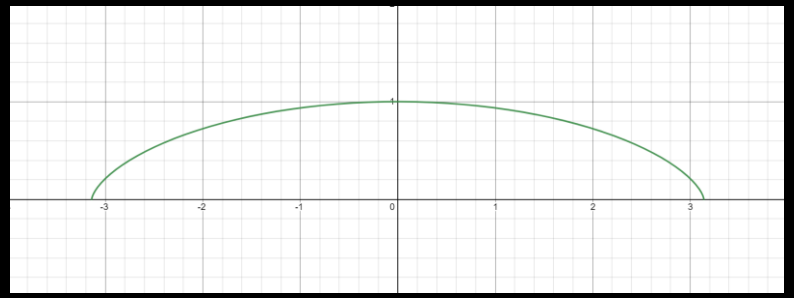


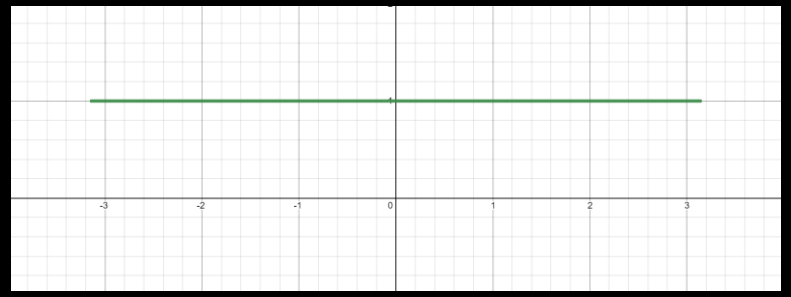
Multi-Frequency Gerstner Wave Composition

Direction Spreading Function



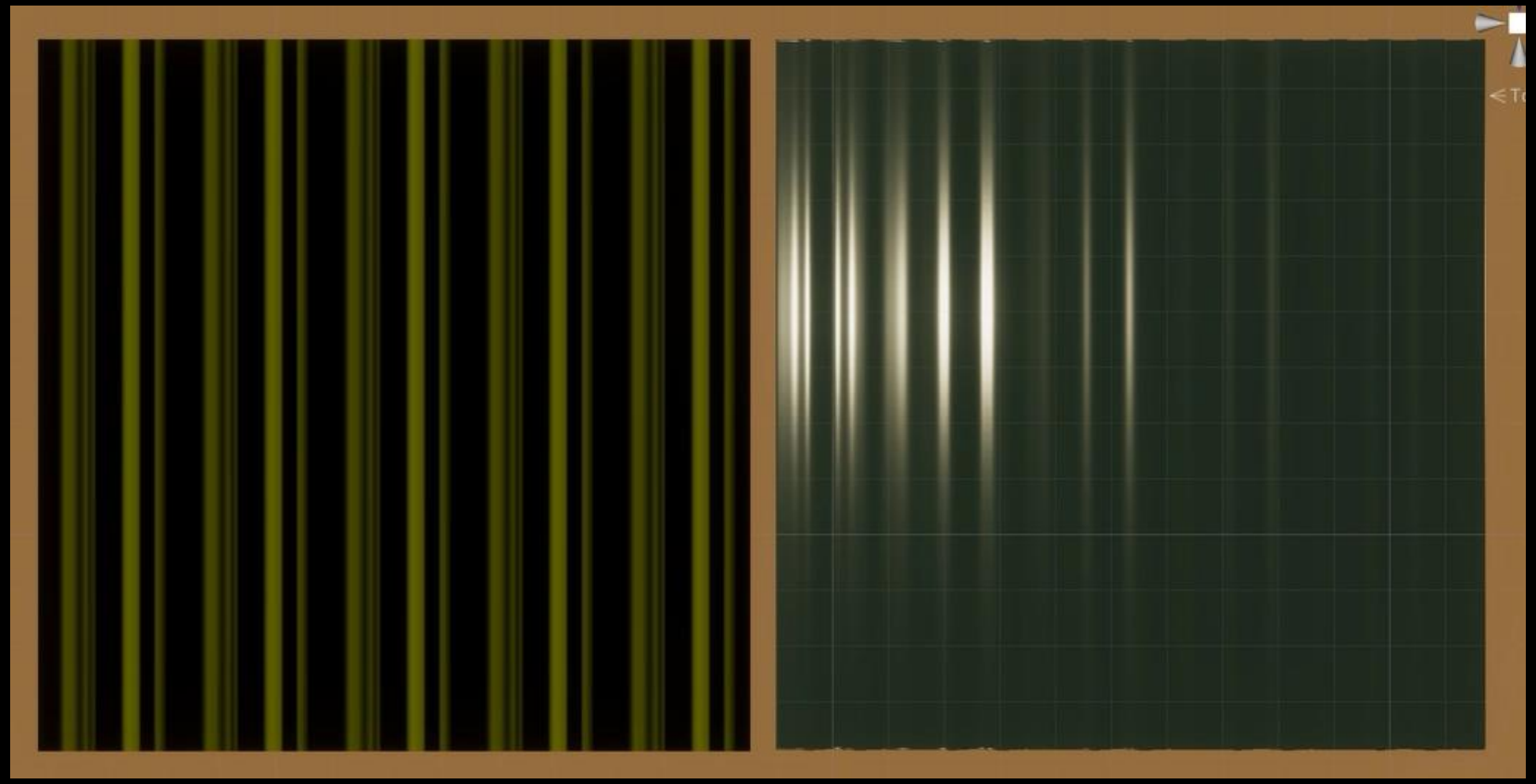






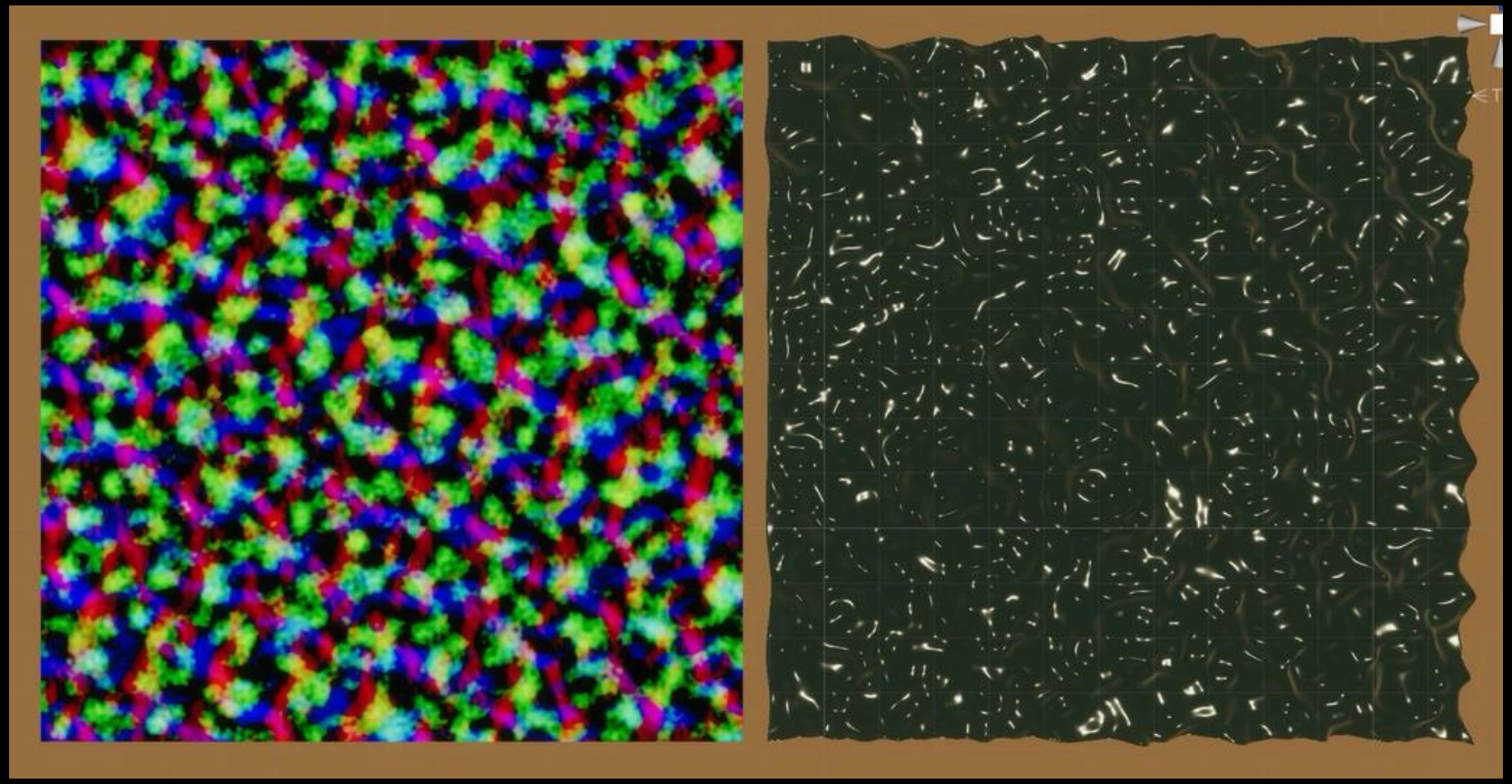
Multi-Frequency Gerstner Wave Composition

1D Wave Profile



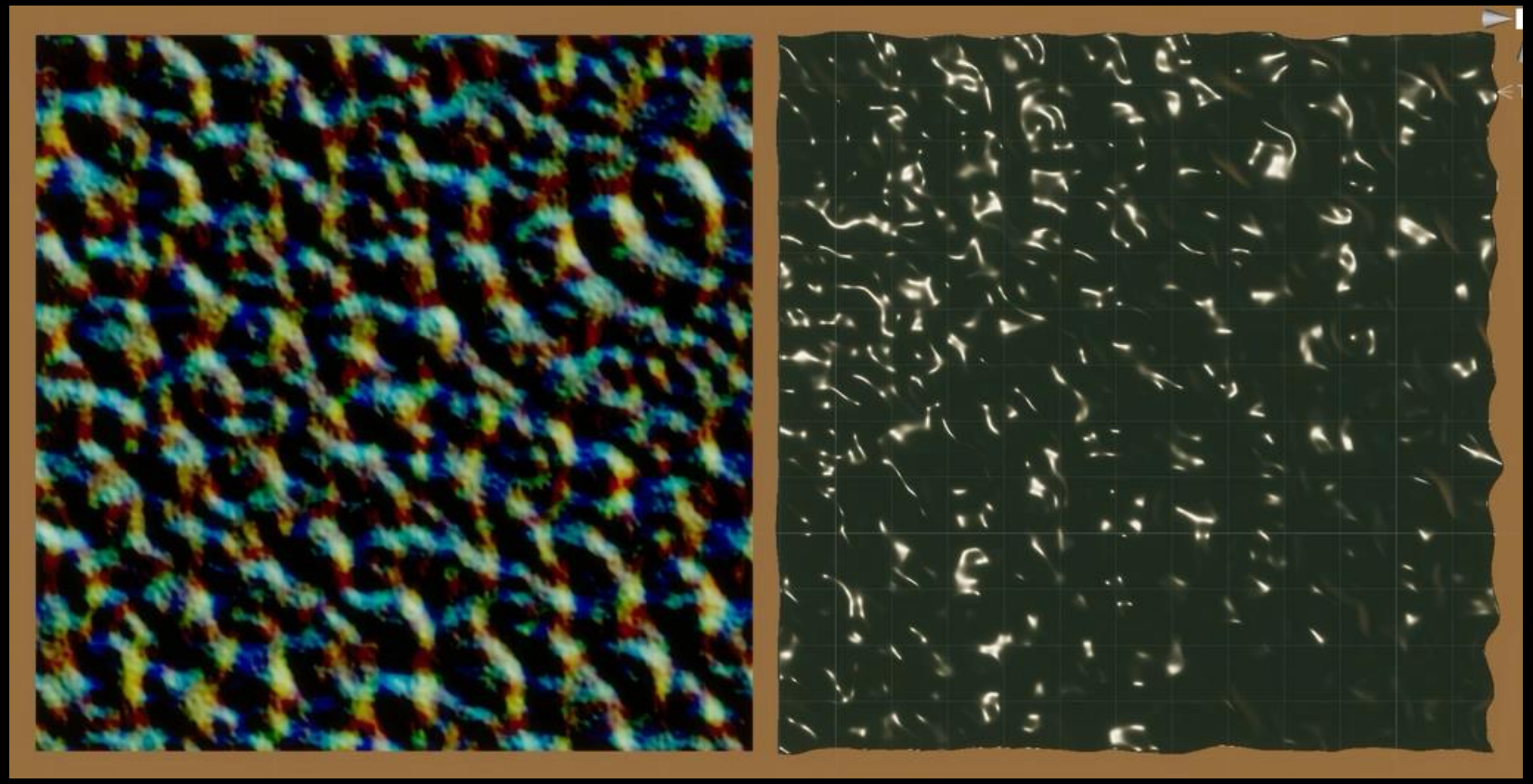
Multi-Frequency Gerstner Wave Composition

Integration

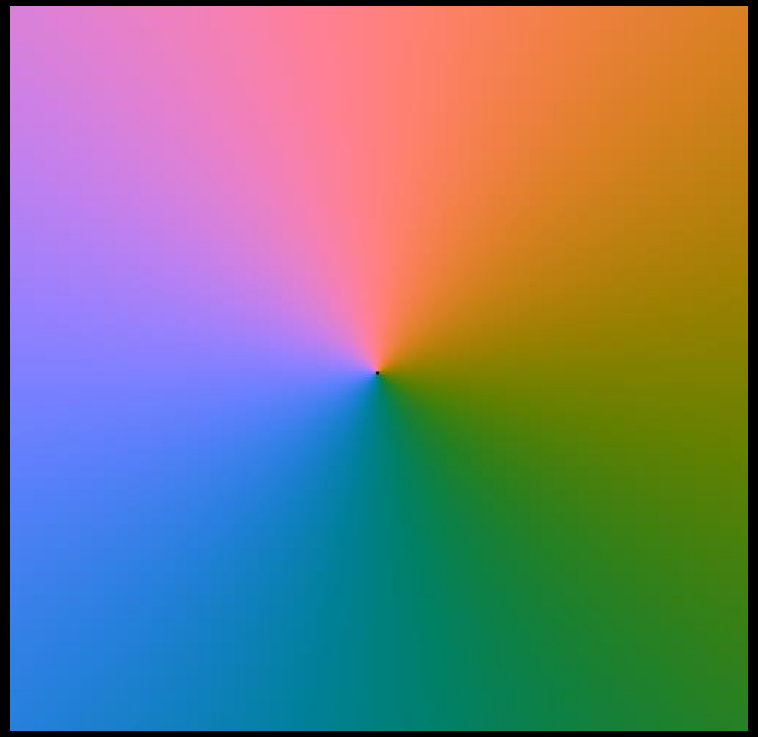


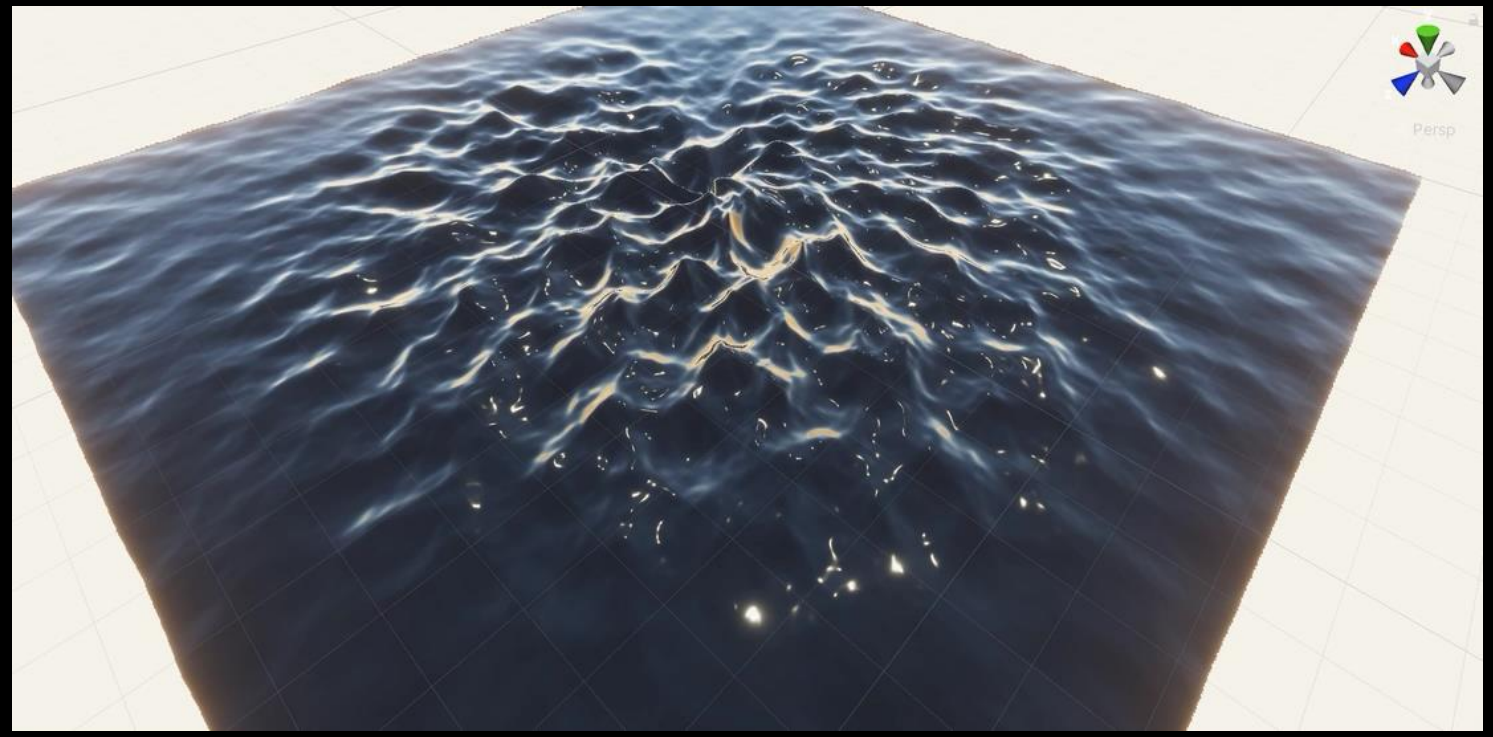
Multi-Frequency Gerstner Wave Composition

Direction Spreading

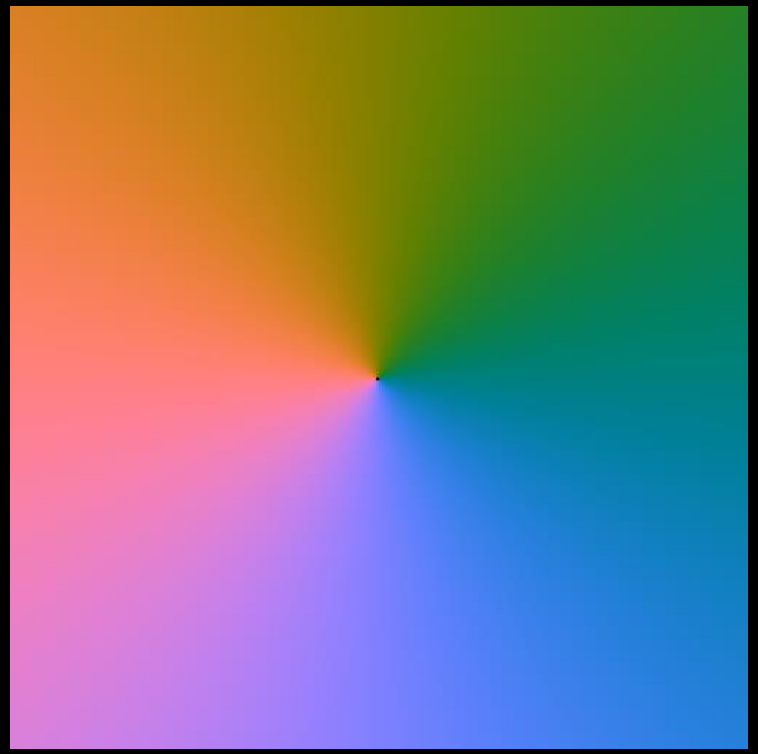


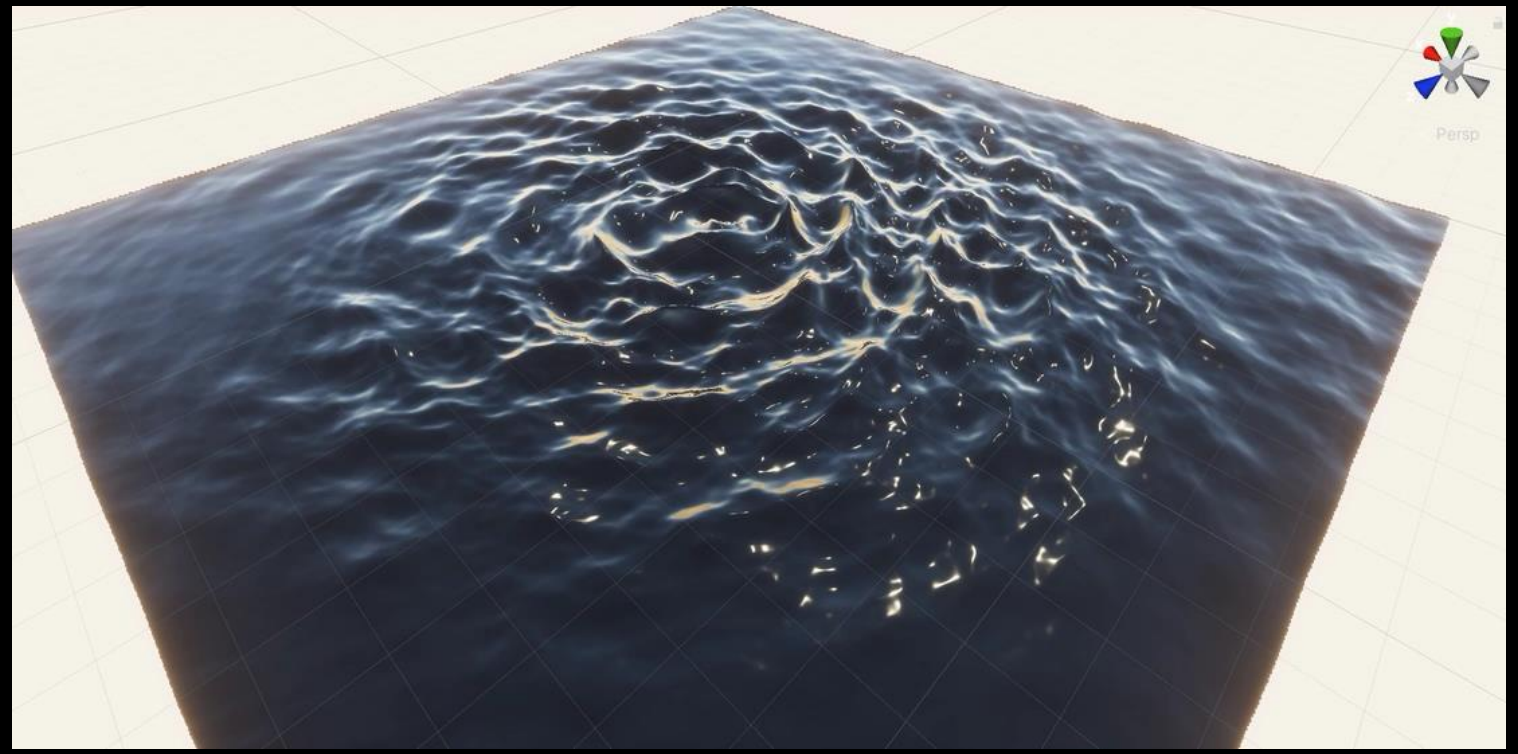
Multi-Frequency Gerstner Wave Composition





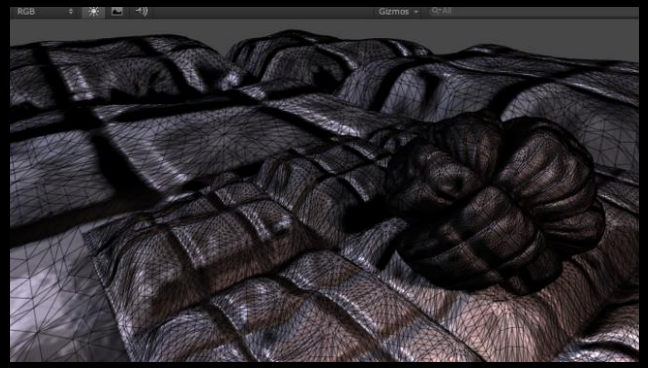
Multi-Frequency Gerstner Wave Composition



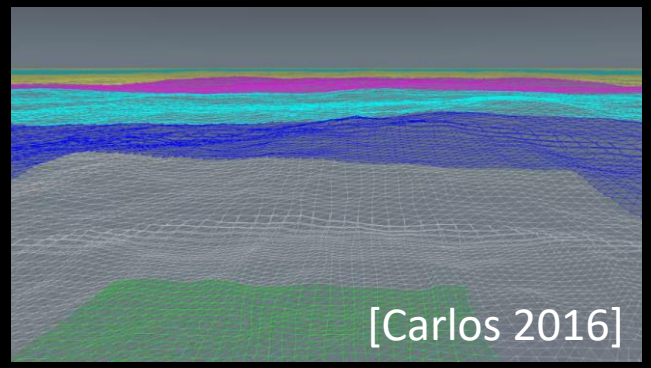


Tessellation

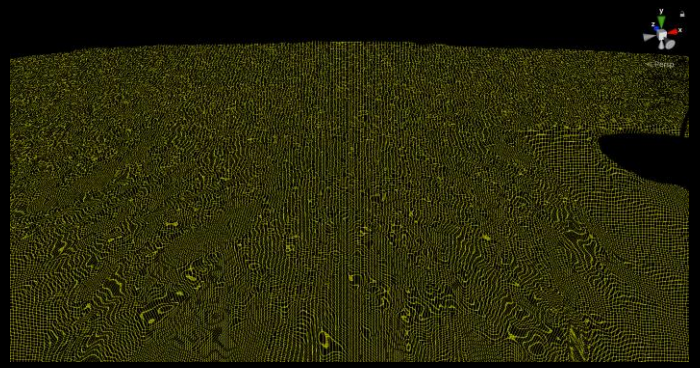
Hardware Tessellation



Cascade Grid

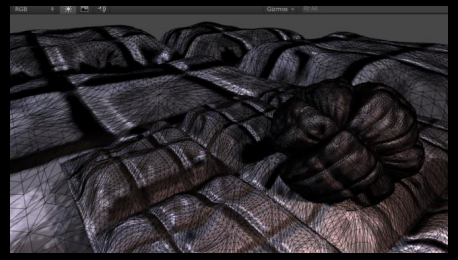


Screen Space Tessellation



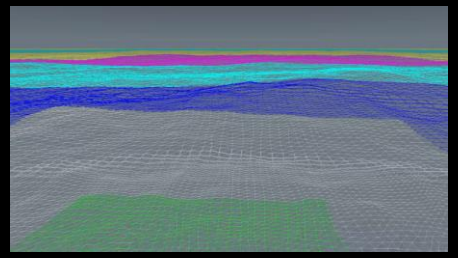
Tessellation

Hardware Tessellation



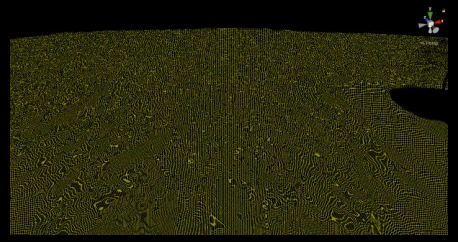
- GPU
- Mannually control density
- Traditional Art Pipeline

Cascade Grid



- CPU & GPU
- Mannually control density
- Extra Art Pipeline

Screen Space Tessellation

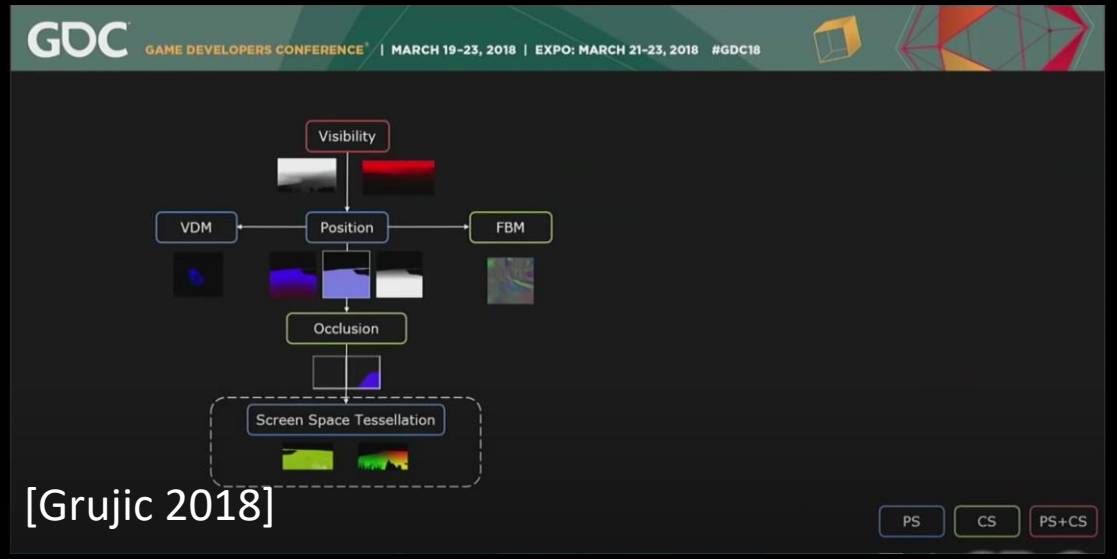


- GPU
- Costant density in screen space
- Traditional Art Pipeline

Screen Space Tessellation Based Water Render Pipeline

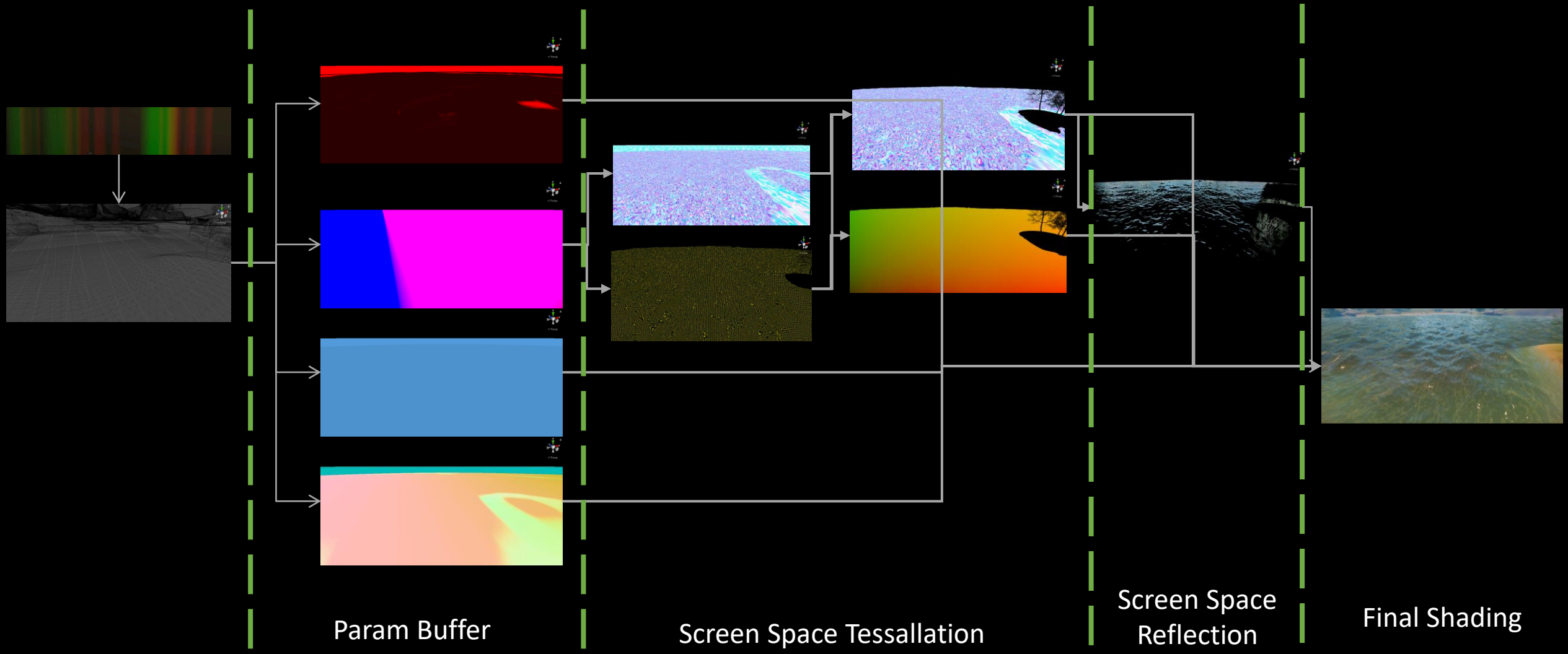
Pretty Similar to [Grujic 2018]

Deferred Shading Pipeline



[Grujic 2018]

Screen Space Tessellation Based Water Render Pipeline



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[Epic 2020] Building Worlds in ‘Fortnite’ With Unreal Engine

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[Evan W. 2016] Rendering Realtime Caustics in WebGL

THANKS