

Annex A – PARAMETERS USED IN Ho³⁺ LASING MODELS

A.1 HO:ZBLAN MODEL PARAMETERS USED IN VALIDATION CASE 1

VARIABLE	SYMBOL	VALUE	UNIT	COMMENT
Signal core radius	A	5	μm	
Core numerical aperture	NA	0.2		Cut-off wavelength: 2.6 μm
Pump core radius	R _{cl}	62.5	μm	
Ionic density	N	5.4 · 10 ²⁰	cm ⁻³	3 mol %
⁵I₅-level:				
Lifetime	T ₄	40	μs	
Zero-line energy	E ₀₄	11270	cm ⁻¹	
⁵I₆-level:				
Lifetime	T ₃	3.5	ms	
Zero-line energy	E ₀₃	8675	cm ⁻¹	
⁵I₇-level:				
Lifetime	T ₂	150	μs	Pr ³⁺ co-doping
Zero-line energy	E ₀₂	5166	cm ⁻¹	
Laser transitions:				
<i>⁵I₆ to ⁵I₇:</i>				
Wavelength	Λ ₃	2.94	μm	
Emission cross-section	σ _{e32}	1.4 · 10 ⁻²¹	cm ²	
Absorption cross-section	σ _{a23}	8.3 · 10 ⁻²²	cm ²	
Fiber attenuation	α ₄	0.21	dB/m	0.1 dB/m ZBLAN + 0.11 dB/m Pr ³⁺
Output mirror reflectance	R ₃	0.04		
<i>⁵I₈ to ⁵I₆(pump):</i>				
Wavelength	λ _p	1.15	μm	
Absorption cross-section	σ _{ap}	1.8 · 10 ⁻²¹	cm ²	
Fiber attenuation	α ₃	0.1	dB/m	
Up-conversion:				
	k ₂₂₄₁	3.2 · 10 ⁻¹⁸	cm ³ /s	
	k ₄₁₂₂	3.2 · 10 ⁻¹⁸	cm ³ /s	
	k ₃₂₁₅	1.0 · 10 ⁻¹⁶	cm ³ /s	

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A.2 HO:ZBLAN MODEL PARAMETERS USED IN VALIDATION CASE 2

VARIABLE	SYMBOL	VALUE	UNIT	COMMENT
Signal core radius	A	5	μm	
Core numerical aperture	NA	0.16		Cut-off wavelength: 2.1 μm
Pump core radius	R _{cl}	25	μm	
Ionic density	N	2.16 · 10 ²⁰	cm ⁻³	1.2 mol %
⁵I₆-level:				
Lifetime	τ ₃	3.5	ms	
Zero-line energy	ε ₀₃	8675	cm ⁻¹	
⁵I₇-level:				
Lifetime	τ ₂	12	ms	
Zero-line energy	ε ₀₂	5166	cm ⁻¹	
Laser transitions:				
<i>⁵I₆ to ⁵I₇:</i>				
Wavelength	λ ₃	3.0	μm	
Emission cross-section	σ _{e32}	3.3 · 10 ⁻²²	cm ²	
Absorption cross-section	σ _{a23}	1.4 · 10 ⁻²²	cm ²	
Fiber attenuation	α ₃	0.05	dB/m	
HR mirror reflectance	R _{HR30}	0.99 or 0.04		
Output mirror reflectance	R ₃	0.04		
<i>⁵I₇ to ⁵I₈:</i>				
Wavelength	λ ₂	2.07	μm	
Emission cross-section	σ _{e21}	0.5 · 10 ⁻²⁰	cm ²	
Absorption cross-section	σ _{a12}	9.3 · 10 ⁻²²	cm ²	
Fiber attenuation	α ₂	0.1	dB/m	
HR mirror reflectance	R _{HR2}	0.6 or 0.04		
Output mirror reflectance	R ₂	0.04		
<i>⁵I₈ to ⁵I₅ (pump):</i>				
Wavelength	λ _p	1.15	μm	
Absorption cross-section	σ _{ap}	1.8 · 10 ⁻²¹	cm ²	
Fiber attenuation	α _p	0.1	dB/m	
Up-conversion:				
	k ₂₂₄₁	2.5 · 10 ⁻¹⁸	cm ³ /s	
	k ₄₁₂₂	2.5 · 10 ⁻¹⁸	cm ³ /s	
	k ₃₂₁₅	1.7 · 10 ⁻¹⁷	cm ³ /s	

A.3 ESTIMATED HO:FLUOROINDATE MODEL PARAMETER VALUES

VARIABLE	SYMBOL	VALUE	UNIT	COMMENT
Signal core radius	A	5	μm	
Core numerical aperture	NA	0.16		Cut-off wavelength: 2.1 μm
Pump core radius	R _{cl}	25	μm	
Ionic density	N	1.8 · 10 ²¹	cm ⁻³	10 mol %
⁵I₅-level:				
Lifetime	τ ₄	30	μs	
Zero-line energy	ε ₀₄	11240	cm ⁻¹	
⁵I₆-level:				
Lifetime	τ ₃	1.1	ms	
Zero-line energy	ε ₀₃	8621	cm ⁻¹	
⁵I₇-level:				
Lifetime	τ ₂	10.2	ms	
Zero-line energy	ε ₀₂	5025	cm ⁻¹	
Laser transitions:				
<i>⁵I₅ to ⁵I₆:</i>				
Wavelength	λ ₄	3.905	μm	
Emission cross-section	σ _{e43}	4.3 · 10 ⁻²¹	cm ²	
Absorption cross-section	σ _{a34}	2.8 · 10 ⁻²¹	cm ²	
Fiber attenuation	α ₄	0.1	dB/m	
Output mirror reflectance	R ₄	0.5		
<i>⁵I₆ to ⁵I₇:</i>				
Wavelength	λ ₃	2.95	μm	
Emission cross-section	σ _{e32}	1.1 · 10 ⁻²¹	cm ²	
Absorption cross-section	σ _{a23}	3.3 · 10 ⁻²²	cm ²	
Fiber attenuation	α ₃	0.1	dB/m	
Output mirror reflectance	R ₃	0.8		
<i>⁵I₈ to ⁵I₅ (pump):</i>				
Wavelength	λ _p	0.895	μm	
Absorption cross-section	σ _{ap}	5 · 10 ⁻²²	cm ²	
Fiber attenuation	α _p	0.1	dB/m	
Up-conversion:				
	k ₂₂₄₁	1.0 · 10 ⁻¹⁹	cm ³ /s	
	k ₄₁₂₂	6.0 · 10 ⁻¹⁸	cm ³ /s	
	k ₃₂₁₅	6.0 · 10 ⁻¹⁶	cm ³ /s	

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