Influence of Pre-discharge on Soft X-ray Amplification in the Fast Gas-filled-capillary Discharge

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Capillary Experiment (*CAPEX***)**

- source of soft X-ray radiation based on the fast capillary discharge
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- Experimental set-up of CAPEX
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- Experimental results
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Experiment CAPEX

- capillary current amplitude 45 kA
- period of capillary current 240 ns
- current rise-time >10¹² A/s
- gas-filled capillary
- amplification of *Ne*-like *Ar* line (3p-3s, J=0-1)

240 ns >10¹² A/s argon 46.9 nm



Experimental set-up of CAPEX



MARX GENERATOR

- 8 stages
- erected capacity 12.5 nF
- short-circuit inductance $14.2 \,\mu\text{H}$
- erected voltage

SPACER (coupling section)		
•	SF_6 as a dielectric	
•	capacitance	10 pF
•	inductance	95 nH
•	a safety interface	



400 kV

Experimental set-up of CAPEX



FAST CAPACITOR

- distilled water as a dielectric •
- 6.0 nF capacitance •
- inductance 68 nH • 3.4Ω
- char.impedance .
- dimensions *\oplus 262 x \oplus 158 x 675 mm*

SPARK GAP

- inner part filled by SF_6 gas ٠
- outer part filled by destilled water • (for capacity enlargement)



Capillary

- ceramic capillary (alumina)
- capillary diameter 3.2 mm
- capillary discharge length up to 180 mm
- gas-filled capillary argon
- filled by a needle valve (continuous flow)
- capillary current amplitude 45 kA
- period of capillary current 240 ns
- current rise-time >10¹² A/s



CAPEX experiment





- no plastic circular ring (*pre-pulse > 50A*)
- plastic circular ring of medium thickness (*pre-pulse* ~ 10-50 A)
- plastic circular ring of full thickness with suitably reduced outer diameter (*pre-pulse 1-30 A*)
- plastic circular ring of full thickness (outer part of the spark gap without water) (*pre-pulse 0.5-1 A*)
- without auxiliary electrode located in water (*no* observed *pre-pulse*)





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Capillary pre-pulse current without spark gap breakdown





Capillary pre-pulse current with spark gap breakdown (t=0)





Experimental results

Measurements of the soft X-ray radiation

- temporal evolution of the soft X-ray radiation measured by PIN-diode
- soft X-ray spectrum measured by home-made flat field spectrometer



Spectroscopic measurements



- toroidal grating Jobin Yvon •
- average groove density 450 gr/mm •

102.57 mm

34x12 mm

30x8 mm

40x5 mm

10-110 nm

- tangential radius 919.0 mm •
- sagital radius •

spectrometer

•

- upper surface dimensions •
- ruled area dimensions •
- spectral interval •
- focused on rectangle •

detection

- 2 MCPs (33x33x1 mm) ٠ (in tandem set-up)
- "phosphor" screen ٠
- CCD camera PCO SensiCam ٠
- clear 30 mm

ITO/ZnS

1280x1024 pixels



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Spectroscopic measurements time-resolved spectrum (50 ns)





Spectroscopic measurements time-resolved spectrum (50 ns)





Conclusions

- an influence of the pre-pulse current on an amplification of *Ne*-like *Ar* line (λ=46.9 nm) was studied
- several configurations of the spark gap was tested (**changing** of the **pre-pulse** current in the range of **0 to 60 A**)
- a strong **amplification** of *Ne*-like *Ar* line ((λ =46.9 nm) was observed for the **pre-pulse** current amplitude of **5** A
- the time-resolved spectrum (**50 ns**) was obtained by homemade soft X-ray flat field spectrometer

plan for a future

- a shorter exposition (10 ns) of the time-resolved spectrum are desirable
- measurement with an other spectrograph (which has a better resolution)

