

7KLUG DQG ILIWK KDUPRQLF L GHQHUDDWA  
XOWUDVKRUW SXOVHV EH\RQG WKH ILIWK

' .DUWDVKRSLãD\$XVNDV\$ \$ 9RU\$QLQ=KHOVDLGR\$ %DOWXã

3KRWRQLFV ,QVWLWXWH 9LHQQD 8QLYHUVLW\ RI 7HFKQR  
\$XVWULD  
3K\VLV 'HSDUWPHQW ,QWHUQDWLRQDO /DVHU &HQWHU  
ORVFRZ 5XVVL  
'HSDUWPHQW RI 3K\VLV DQG \$VWURQRPL 7H[DV \$ 0 8QLY  
86\$

\$EVWUDKWLUG DQG ILIWK KDUPRQLF JHQHUDWLRQ E\ XOWU  
LQIUUDHG UHYHDOV QRQOLQH DU RSWLFD O HIIHFV EH\R  
HQDEOHV GXH WR DQ H[WUDRUGLQDULO\ ORQJ FRKHUHQF  
XSFRQYHUVLRQ RI XOWUDVKRUW PLG ,5 SXOVHV

+DUPRQLF JHQHUDWLRQ LV RQH RI WKH IXQGDPHQWDO HII  
WKH KH DUW RI HIIFLHQW IUHTXHQF\ FRQYHUVLRQ VFKH  
DGYDQFHG DWRVHFRQG WHFKQRORJLHV > @ :KLOH KLJ  
UHJLPH HQDEOHV WKH V\QWKHVLV RI XQSUFHGHQWHGO\  
XVHG IRU QRQSHUXUELQJ PHDVXUHPHQWV RQ DWRPLF D  
SDUDPHWHUV RI PDWHULDOV LQFOXGLQJ WKHLU RSWLFD  
QRQOLQH DU RSWLFD LQ WKH PLG LQIUUDHG > @ FDOOV  
WKH PLG ,5 7KH ILUVW H[SHULPHQWV RQ WKH ILODPHQW  
HIIHFV DQG XQXVDO UHJLPHV VXJJHVWLQJ QHZ SK\VL  
RI ILHOG ZDYHIRUPV LQ WKLV VSHFWUDO UDQJH DQG UHTX  
SXOVH HYROXWLRQ 7KH ODWHVW EHDNWKURXJKV LQ V  
GHOLYHULQJ V\QVHV ZLWK ZDYHOHQJWKV ZHO O EH\RQG  
LGH SWK VWXGLHV RI RSWLFD QRQOLQH DULWLHV LQ WKH  
JHQHUDWHG LQ WKH UHJLPH RI ZHDN GLVSHUVLRQ DQG KH  
+HUH ZH H[SHULPHQWDO\ GHPRQVUDWH DQG WKHR  
JHQHUDWLRQ SXOVHV RI -P UDGLWLRQ ZLWK D SHDN SF  
FROOLPDWHG EHDV ([SHULPHQWV ZHUH SHUIRUPHG ZLW  
ODVHU V\VWHP GHOLYHULQJ +] IV ODVHU SXOVHV DV  
FROOLPDWHG EHDV RXSXW RI WKLV V\VWHP ZLWK D EHDV  
DQG ILIWK RSWLFD KDUPRQLFV DORQJ D VWUDLJKW SUP  
LQIUUDHG DQG YLVLEOH 89 VSHFWURPHWHUV ZHUH XVHG  
KDUPRQLFV FRYHULQJ WKH VSHFWUDO UDQJHV RI

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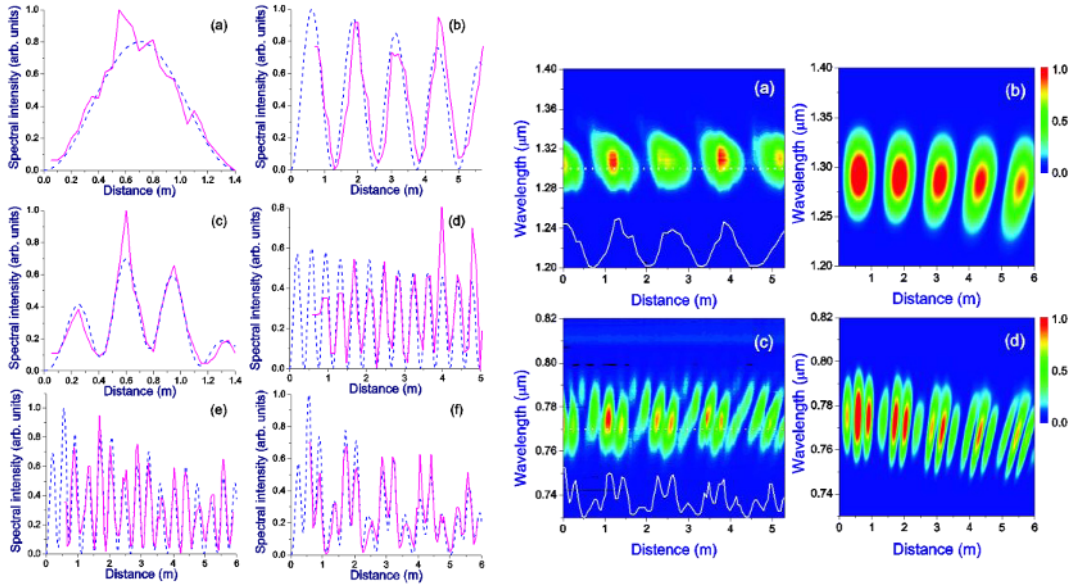


Fig. 1. /HISVDQHO ,QWHQVLWLHV RI WKH WKLUG BRQLF VEP HDQV UHGWKV FDOFXODWHG HQG VKH G IXQFWLRQ RI IW KHLSS SRBSS JDXOLVHQ/ SLDWKUR LQ WKH DWPRVSKHFKLH SDLPB HXQKUP- G P- FH I F5LJW SDQH VSHFWUD RI WKH WKLUG DDPREQLF QGP HLDWKUHF G F DQG FDO SURSDJDLWRQ SDWKV RI WKH SXPSK DUHQFRQ ILQ WKLUG DWDP RSKD WL YHUWLFDO OLQHV LQ WKH PDS DUH VKRZQ RQ WKH ULJKW RI WK

QRQOLQH DU LQWHUDFWLRQ RQ WKLUG WKLUG %DVSODULHG GZLWKWK B SURYLGLDWWHQXDWRQ RI WKH PLG 5 OLJKW 7KH LQWH D IXQFWLRQ RI WKH LQWHUDFWLRQ OHQJWK E\ VFDQQLQJ V 5HVXOWV RI WKLUG DQG ILIWK KDUPRQLF JHQHUDWRQ SUHVHQWHG LQ )LJ ,QWHQVLWLHV RI WKH WKLUG DQ PHDVXUH DV D IXQFWLRQ RI WKH SURSDJDLWRQ OHQJWK LQGLFDWLQJ ODUJH FRKHUHQFH OHQJWKV IRU KDUPRQLF LQ WKH ULJKW SDQHO RI )LJ UHIOHFWV WKH ZDYHOHQJV JHQHUDWRQ SURFHVVHV DVVRFLDWHG ZLWK JDV GLVSHU 2XU PRGH RI KDUPRQLF JHQHUDWRQ E\ XOWUDVKRUW RI WKH JHQHUDOLJHG 6FKUJGLQJHU HTXDWRQ IRU WKH SXUSRVHV RI WKLUG ZRUN WR LQFOXGH WKH WHUPV GHVFUL

$$\frac{\partial \tilde{E}}{\partial z} = [i\hat{D}(\omega) - \alpha(\omega)]\tilde{E} + \frac{i\omega}{2c} \hat{F} \left\{ \sum_{m=1}^4 \chi^{(2m+1)} E^{(2m+1)} \right\} \quad (1)$$

+HUVV WKH FRRUGLQDWH DORQJ  $z$  ISU RSKHD RUXURQH GLW WKH HOHFWELE (E) ILHOGWKH WLPH LQ WKH UHWDZLGH GVIWDKPH IUHTXHQF) WKH )RXULHU WUDQVIRWLP- RSKDULDW (R $\omega_0$ ) LV WKH GLVSHUVRQ RSHUHQWHHQWUDO IUHTXHQF E\ (R)c V (KH ILQ SSKWH UHIUDFWLQJ ILQ WKLUG DEVRUSWV RQKFRVH HLFGRQ W $\chi^{(m)}$  KLW LQK N mWRUGHU QRQOLQH DU VXFHSWLELOLW\ \$ORQJ ZLWK GLU (T ZULWWHQ IRU WKH HOHFWULF ILHOG LQFOXGHV V SXOVH VHOI VWHSSHQLQJ \*DV GLVSHUVRQ DQG DEVRUS

IRUPXOD IRU DUJRQ DQG WKURXJK WKH 0DWKDU PRGHO >  
 FDVH RI DWPRVSKHULF DLU  
 7KH PRVW VWULNLQJ IHDWXUH RI WKH ILIWK KDUPRQLF  
 ZDYHIRUP RI LWV IULQJHV GSHQGV RQ WKH SXPS LQWH  
 FDQRQLFDO VROXWLRQ WR WKH VORZO\ YDU\LQJ HQYHORS  
 $\chi^{(3)}$  DQG WHUPV ZKLFK SUFDOLWVRWK ERWK GLUHFWDQG FD  
 ZLWK WKH SXPS KLOWHQWHLW\ GSHQGHQFH RI WKH ZDY  
 FDQQRW EH H[SODLQHG LQ WHUPV RI D SHUWXUEDWLYH W  
 $\chi^{(8)}$  DQG WHUPV GLUHFWO\ LQGLFDWLQJ WKH LQIOXHQF  
 VXJJHVWLQJ D PHWKRG IRU PHDVXULQJ KLJK RUGHU QRQ  
 QRQOLQHDU RSWLFDO VXVHSHWLELOLWLHV IRXQG IURP WK  
 H[SHULPHQW $\chi^{(8)}$  UHVXOW $\chi^{(9)}$  LV FP 9  $\chi^{(7)}$  FP 9 DQG  
 $\chi^{(9)}$  FP 9  
 ,Q VXPPDU\ WKLUG DQG ILIWK KDUPRQLF JHQHUDWLRQ  
 DQ[WUDRUGLQDULO\ ORQJ FRKHUHQFH OHQJWK UHYHDO  
 QRQOLQHDULW\ :LWK WKH ZDYHOHQJWKV RI WKH VHYHQW  
 DOVR IDOOLQJ ZLWKLQ WKH WUDQVSDUHQF\ UDQJH RI D  
 DOORZLQJ FRPIRUWDEOH GHWHFWLRQ WKH FROOLPDWHG  
 LQ WKLV ZRUN FDQ EH UHJLQO\ JHQHUDOL]HG WR WKH PH  
 RUGHUV

5HIHUHQFHV

- 1 %ORHPEHILHQC %HQMDPLQ 5HDGLQJ 0\$  
 - ) 5HLQWHV *Optical Parametric Processes in Liquids and Gases* 2UODQGR  
 \$FDGHPLF
- \$ 6TXLHU 0 0•OOHU \* - %UDNHQKRBI DQG . 5 :LOVR  
 P. B. Corkum and F. Krausz, *Nature Phys.* **3**, 381 - 387 (2007).
- \* \$QGULXNDLWL 7 %DOFLXQDV 6 \$OLVDXVNDV \$ 3  
 &KHQ 0 0 0XUQDQH DQG +36& .DSWH\Q 2SW /HWW
- \* 2 \$ULXQEROG 3 3RO\QNSW DQGHV 0RORQH\  
 ' 9 .DUWDVKRY 6 \$OLVDXVNDV \$ 3XJãO\V \$ %DOW  
 3HWUDUFD 3 %HBRWUDID.DWSDULDFV 8)2 9,,, 0RQWHU
- 5 - 0DW\$SDU432SW ±  
 KWWS ZZZ FID KDUYDUG HGX KLUWUDQ