

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

' .DUWDV KR\$YOLãD\$XVNDVãD\$ 9RU\$QLQ=KHOVDLQR\$ %DOWXã

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

\$EVWUDKLUG DQG ILIWK KDUPRQLF JHQHUDWLRQ E\ XOWU
LQIUUDHG UHYHDOV QRQOLQH DU RSWLFD 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 SXOVHV ZLWK ZDYHOHQJWKV ZHOH 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
FROOLDWHG EHDV ([SHULPHQWV ZHUH SHUIRUPHG ZLW
ODVHU V\WHP GHOLYHULQJ +] IV ODVHU SXOVHV DV
FROOLDWHG EHDV RXSXW RI WKLV V\WHP 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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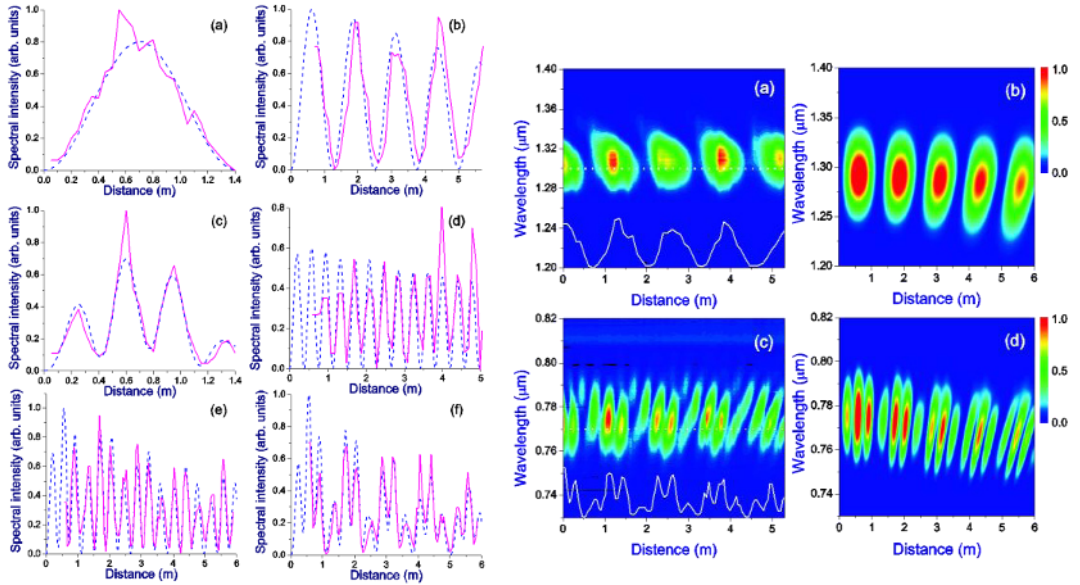


Fig. 1. /HISVDQHO ,QWHQVLWLHV RI WKH WKLUG BRQ LDF VEP HDQV UH GW KV FDOFXODWHG HQG VDKH IXQFWLRQ RI IW KHLSS SRBS SDXVLRQ/ SDWKU R LQ WKH DWPRVSKHFKLH SDLPB HXQKUP- G P- FH I F-LJW SDQH VSHFWUD RI WKH WKLUG DDPREQLF QGP HLD WKUHFQ F DQG FDO SURSDJDWLRQ SDWKV RI WKH SXPSK DUHFORQ ILQ WKLUG DWPRVSKH WIL YHUWLFDO OLQHV LQ WKH PDS DUH VKRZQ RQ WKH ULJKW RI WK

QRQOLQH DU LQWHUDFWLRQ PWRWQLWV ZDVSODULHG QZLWV D SURYLGLDWWHQXDWLRQ RI WKH PLG 5 OLJKW 7KH LQWH D IXQFWLRQ RI WKH LQWHUDFWLRQ OHQJWK E\ VFDQQLQJ V 5HVXOWV RI WKLUG DQG ILIWK KDUPRQLF JHQHUDWLRQ SUHVHQWHG LQ)LJ ,QWHQVLWLHV RI WKH WKLUG DQ PHDVXUH DV D IXQFWLRQ RI WKH SURSDJDWLRQ OHQJWK LQGLFDWLQJ ODUJH FRKHUHQFH OHQJWKV IRU KDUPRQLF LQ WKH ULJKW SDQHO RI)LJ UHIOHFWV WKH ZDYHOHQJV JHQHUDWLRQ SURFHVVHV DVVRFLDWHG ZLWK JDV GLVSHU 2XU PRGH RI KDUPRQLF JHQHUDWLRQ E\ XOWUDVKRUW RI WKH JHQHUDOLJHG 6FKUJGLQJHU HTXDWLRQ 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 ISVRSCHD RUXURQH GLW WKH HOHEWELH $E(z, t)$ ILHOGWKH WLPH LQ WKH UHWDZLGH GVIWDKPH IUHTXHQF WKH)RXULHU WUDQVIRWLP- RSDU DW $\omega = \omega_0$ LV WKH GLVSHUVLRQ BSHUWHWRHQWUDO IUHTXHQFH ω $\chi^{(m)}$ ILQ SVKWH UHIUDFWLQJ ILQWKH DEVRUSWV RQKFRVH HLFGRQ $\omega_0^{(m)}$ KLW MCKNY m WRUGHU QRQOLQH DU VXFHSWLELOLW \$ORQJ ZLWK GLU (T ZULWWHQ IRU WKH HOHFWULF ILHOG LQFOXGHV V SXOVH VHOI VWHSSHQLQJ *DV GLVSHUVLRQ 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 KLQWHQWHQVLW\ 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[SHULPHQWDO UHVXOWV $\chi^{(5)}$ $\chi^{(7)}$ 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\ JHQHUDOLJHG WR WKH PH
 RUGHUV

5HIHUHQFHV

- 1 %ORHPEHILHJ %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