

ARTS2128

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 $\label{eq:hamiltonian} $$HY'GW.cc``cZh,Y'5ftg'UbX'AYX]U'k ci`X``]_Y'tc'FYgdYWM\cong \cong m5W_bck``YX[Y'th,Y'HfUX]tjcbU``7i gtcX]Ubg\cong hY'6YXY[U'``fPYbg]b[tcb'WJa di g\cong \cong \cong \cong mUbX'5fti/'8Yg][b'7Ua di gYg\cong \cong \con$

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7 fYX]hDc]bhg**

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5ffjgfjWghfUhY[]Ygʻdfcj]XYʻdck YfZ ``a YUbgʻcZa U_]b[ˈgcWJU``UbXʻdc`]hJWU``a YggU[Ygʻ\YUfXʻVm'Uk]XYf Ui X]YbWY"'7i `hi fYʻUa a]b[žZUg\`a cVgž[i Yff]``Uʻh\YUhfYžUbXʻcb`]bYʻUWfj]ga '`UfY`a U_]b['`Ub']a dUWh UWfcggʻdc`]hJWD``WUa dU][b]b[žgcWJU``UXj cWUWhžUbX`Wca a i b]ma cV]`]gUhjcb"'H\]gʻWci fgY`k]``]bhfcXi WY mci 'hcʻg][b]ZJWUbhXYj Y`cda YbhgʻUbX`XYVUhYgʻUVci hi g]b['Ufhhcʻ]bgd]fY`WXUb[YʻUbX`hcʻ]bhYfj YbY`k]h\]b di V`]WgdUWY"'Mci 'k]```\Uj Y`Ubʻcddcfhi b]mhcʻk cf_k]h\`mci fʻdYYfgʻhcʻXYj]gY`mci fʻck bʻZcfa 'cZUWfj]ga 'cf Wca a i b]mhYb[U[Ya YbhUfci bX`Ubʻ]ggi Y`cZmci fʻWxc]WY"

7 ci fgY @YUfb]b['Ci hWca Yg

- %" ⇒ YbhjZmg][b]Zj\Wbha ca Ybhg`UbX`XYVUhYg`]b`h\Y`XYj Y`cda YbhcZdi V`]\WUfhž`U\Mjj]ga ž`UbX`h\Y dc`]h\\g`cZdi V`]\WgdU\\']b`h\Y`&\$h\`UbX`&\\gh\\bh f]Yg```
- &" 5ggYgg`_Ymih\YcfYh]WU``WcbWYdhg`Ug`k Y```Ug`dfUWf]WU``a cXYg`cZUWhjj]ga `UbX`di V`]WUk UfYbYgg! fU]g]b[ž'UbX`Udd`mih\Ya `hc`WcbhYa dcfUfmi]gqi Yg````
- ' "Kcf_`Wc``UVcfUhjjY`mk]h\`ch\Yfg`]b`ibXYfhU_]b[`fYgYUfW\`UbX`dfYgYbhUhjcb`cZZjbX]b[g````

HYUWX]b[GhfUhY[]Yg

F YUX]b[gžj]XYcgžUbX`U`Wca V]bUh]cb`cZcb`]bY`UbX`ZJWY!rc!ZJWY`YWi fYg`k]``dfcj]XY`\]ghcf]WD``WcbhYI h UbX`Wf]h]WU``hYfa]bc`c[mZcfi bXYfghUbX]b[`h\Y`j Uf]ci g`]bhYffY`Uh]cbg`VYk YYb`UfhUbX`UWfj]ga "``5`Z]ddYX a cXY``cZh hcf]U`g`k]``gi ddcfnghi XYbh`YX`Yb[U[Ya Ybhk]h\`]ggi Yg`UbX`WJgY`ghi X]Yg`cZh\Y]f`ck b \\\ccg]b[ž`YUX]b[`hck UfX`h\Y`XYj Y`cda YbhcZh\Y`Z]bU``[fci d`dfc^YWih\UhXYj]gYg`U`k Umhc`a cV]`]gY`di V`]W Uk UfYbYgg`Ufci bX`U`W ffYbh]ggi Y"

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K YY_'&.', '>i bY'!'%& >i bY	@YWh fY	Bch\]b['UVci hi g'k]h\ci hi g . 'K cf_]b['k]h\ Wca a i b]hm'BgT'{U Scf S`V b'ab Scf - Ua_g` [fk Scf - eaU[S^bc5Uf[UWeaU[S^k W YSYW Scf/E 73fi [fWchW f[a`hž['fWrc5f[a`- Scf SeZ['Y - WfZ[Ue aX bScf[U[bSf[a`S`V Ua_g` [fk W YSYW_W f
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K YY_" .'%) '>i bY'!'% >i bY	@YWi fY	GdUWY']bj UXYfg . 'GdUWYz'dck Yfz'UbX U[YbWn''6 [eU[b]' Sok bai Wd fZWbS abf[Ua S'V egchW[^S UWebSUW a Zb'SUWe - YW VWdW S'V cSU[S]eW ebSUW i S] [Y Se Scf- bekUZaYWaYcSbZk ł _ [eZYg[VWełS'V afZWd UdWSf[hWSUf[hSf[a aXebSUW
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K YY_'(.'&&'>i bY'!'&* >i bY	@YWn fY	H\Y'Wcbgi a Yf'ghf]_Yg'VUW'DYfZcfa]b['h\Y Wcbgi a Yf'''? [_ We[e S`V Ua`eg_ WdWj bWdW UWe- TcS`VeUSbWe-W_ af[a`S^^STagd- ZST[fge - Ug^fgdW 'S [`Y-eSf[dWS`V bcS`]efWde
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6cmXž5bXfYk žUbX`8Uj Y`Cgk U`X`A]\\\XY``žYXg"ž4\\Sgf[\Xg^FcagT\\ 3 Faa\Taj \XadD\\\ha\gf[a``fBYk`\\\cf_UbX`@cbXcb.`C\#\`6cc_qž\&\\$\\&\

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\ci fg'UfY', .\$\$Ua '-'%\$.\$\$da 'cb'k YY_XUmg'UbX'-.\$\$Ua '-').\$\$da 'cb'k YY_YbXg'fl *) 'XUmg'U'mYUft"'=Z'mci
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]bWi XY'Ug'Yj]XYbW' 'hc'gi ddcfhmci f'Y! hy'bg]cb'Udd']WUh]cb"'=Zmci 'Ya U]''9! hy'fbU''Gi ddcfhmci 'k]'`
Ui hca Uh]WJ'`mfYW']j Y'U'h]W_Yhbi a VYfZ'Vi h]Zmci 'hY'Yd\cbY'mci 'k]``bYYX'hc'gdYW]Z]WJ'`mUg_'Zcf'cbY''
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; YbYfU`mž'UggYgga YbhiHug_g'a i ghVY'gi Va]hhYX'Y`YVWfcb]\WJ``mij]U'Y]h\Yf'Hi fb]h]b'cf'U'A ccX`Y Ugg][ba Ybh''=b']bgHJb\W'g'k \YfY'h\]g']g'bchdcgg]V`Yž']hk]```VY'gHJhYX'cb'mci f'\\circ i fgY'g'A ccX`Y'g]hY'k]h\U`hYfbUh]j Y'gi Va]gg]cb'XYHJ]`g"

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D`U[]Uf]ga i]gii g]b[ih\Yik cfXgicfi]XYUgicZch\YfgiUbXidfYgYbh]b[ih\Ya iUgimci fick b"i=hWJbihU_Yia Ubm Zcfa gžZfca iXYi]VYfUhYiWXYUh]b[ihciUWW]XYbhU`mWcdm]b[iZfca iUigci fWYik]h\ci hiUW_bck iYX[Ya Ybh'

IBGK [fcidg'd'U[]Uf]ga]bhc'h\Y'Zc``ck]b['WUhY[cf]Yg.

- i bXYfgfUbX mci f'f][\hg'UbX'fYgdcbg]V]`]hJYg'Ug'U'gh XYbhUhl BGK
- VY`Uk UfY`cZd`U[]Uf]ga ž`Wcdmf][\hz'l BGK `Gh XYbh7cXY`cZ7cbXi WhUbX`5VWWdhUV`Y`l gY`cZ I BGK `=\forall H`F Ygci f\W\g`Dc`]\m\m
- VY 'Uk UfY 'cZh\Y 'ghUbXUfXg 'cZVY\Uj]ci f'Yl dYWYX 'cZYj YfmcbY ']b 'h\Y 'l BGK 'Wca a i b]hm
- `cWUHY 'gYfj]WYg'UbX ']bZcfa UH]cb'UVci hI BGK 'UbX'I BGK '@]VfUfm

Gca Y'cZh\YgY'UfYUg'k]``VY'ZJa]`]Uf'hc'mci ž'ch\Yfg'k]``VY'bYk"'; U]b]b['U'gc`]X'i bXYfgHJbX]b['cZU``h\YfY`UhYX'UgdYWng'cZ9@+69'k]``\Y`d'mci 'a U_Y'h\Y'a cghicZmci f'ghi X]Yg'UhI BGK "'\\hd.##qi VYWfi |XYg"`]VfUfm'i bqk "YXi "Ui #\`]qY#JVci hY`]qY

5 WUXYa]W + DZcfa Uh]cb

: cf'YggYbhJU`ghi XYbh']bZcfa UhJcb'fY`UhJb['hc.

- fYei Yghg Zcf Yl hYbg]cb/
- `UhY 'gi Va]gg]cbg'[i]XY`]bYg/
- fYj]Yk 'cZa Uf_g/I BGK '<YU'h\ 'UbX'GUZYhmdc']W]Yg/