O u $\sim!$ y!Pu y !E gyuw $\sim!$ Pu !au y ! $\sim!$ M O $\sim!$ Wu!

wu!u x!

Pzdzlzz RaTiÅ5 HdÅQzz

Credit: Y. Beletsky (LCO)/ESO

<u>iz 6b</u>

g l Åz Å Sz f z 6T Å Åz P z d z l z z

Nu yx!!

zq <u>PAF=?AAD</u> mzzgzfz 5Pdl5lz f z5kzzezz R a T i Å bblÅQzz

center for **O** h energy physics



भारतीय विज्ञान संस्थान

kz RÅ











g wyĘe u u!au~u y

T !m ! y!xy yw!Pu !au y !K



"That isn't dark matter, sir—you just forgot to take off the lens cap."



____**_**_





Szfz6ÅÅ



Fig.: 2302.02372

Ζ

Szfz6ÅZz



hu !v ! gu y !Y&ku 4 10a !: 8: =

Szfz6ÅZz





W7HPil8Pz l ~ z



Qu ! y! y! y!g !u ! !Pa!xy yw !K





Sz fz Åz











$$\Gamma_{ann} = rac{C_{\odot}}{2}$$





 $\mathring{A} \sim b \mathring{A} R \sim z S R$





W 7Å $HbÅ R \sim R z \sim z$

g

d Æf&gw u

 $\mathring{A} \sim b \mathring{A} R \sim z S R$





W 7Å Ht z S z



g

d Æf&gw u

$\sim b A R \sim z S R$



g



h



huu !bu !au 4MXg4gu~ !a xu4u x!fu u !Yu u Oz q H<u>AF</u>=?AAD

<u>iz 6bb</u>

a i z Q z Å a S z f z

e z 6 Pz d z 1 z z

Pdl5i z izzz5P~ l 5kzzezz



TzziQa



Quui II yw IE

$$\frac{d^2 N_i}{dEdt} = \frac{1}{2\pi\hbar} \sum_{dof} \frac{\Gamma_i(E, M_{\rm PBH}, a_*)}{e^{E'/kT_{\rm PBH}} \pm 1}$$



Tzz iQa



Å i Qa N



a

Å i Qa N



a

ЕЛьи 6 х7 у уу5ь и Льи 55 у уу5ь и 7

bX f

Ζ

i Qa Sf



$\begin{array}{ccc} p & z \\ z & bXf \end{array}$




pzez6 N



e z 6 z











e z 6



E77u 6wu6yx7 ~7Yu 5u u5zy6







Ζ

h_iEfSsaly yu y



cvuyx! ~!PuT !OD8= @ D: DAI



bXf z e z 6

c v u y x z ! x x u uu! u ! u x! y! y ~!Y u 5 x! z y ! x u u y ! O N c g g ta V Q y u to





Oyx ÆQ u !h yyxy!d ~u 7k ¢a ¢Xyw!cvy u



R Å

- Py! !Pa5yyw ! w y ~4 w !Pa! u wy !w !~y !w yx! xy! y! g &
- hyy!wu yx!Pa!u wy!wu!u uy!ux! xwy!y ! u!wu! vy!xyywyx!v!yy u!y y y ! y!wbyOvy4PyyOy4Fi ~! y! uy !xuu5y !z ! yy!y y y ! y!vu! x5yux ~!v x! !Pa5yyw !wuy ~!w 5yw 6
- 12!Pa!!!z !z!yu u ~!dNT 4-y!wu!uzzyw!y!y yu y!z! USa
- •i ~!y ~!Y u 5α!z y !xu u y 4 y! ! ~! ! y! z uw ! z!Pa! uxy! ! z!aNT!Pa6

R Å

- Py! !Pa5yyw ! w y ~4 w !Pa! u wy !w !~y !w yx! xy! y! g &
- hyy!wu yx!Pa!u wy!wu!u uy!ux! xwy!y ! u!wu! vy!xyywyx!v!yy u!y y y ! y!wbyOvy4PyyOy64i ~!y! uy!xuu5y!z ! yy!y y y !y!vu! x5yux ~!v x! !Pa5yyw !wuy ~!w 5yw 6
- 12!Pa!!!z !z!yu u ~!dNT 4-y!wu!uzzyw!y!y yu y!z! USa
- •i ~!y ~!Y u 5α!z y !xu u y 4 y! ! ~! ! y! z uw ! z!Pa! uxy! ! z!aNT!Pa6

hu !m

Q u!g xy



Target materials for electron recoils?

Туре	Examples	mass threshold	ΔE
Noble liquid	xenon	~5 MeV	~10 eV
Semiconductor	silicon	~500 keV	~1 eV
Scintillator	gallium- arsenide	~500 keV	~1 eV
Many other ideas	Graphene, superconductors, Dirac materials, polar crystals	various (> keV)	various (> meV)

Hochberg, Kahn, Lisanti, Tully, Zurek Hochberg, Zhao, Zurek Hochberg, Pyle, Zhao, Zurek Hochberg, Lin, Zurek Hochberg, Kahn, Lisanti, Zurek, Grushin, Ilan, Griffin, Liu, Weber, Neaton Knapen, Lin, Pyle, Zurek Griffin, Knapen, Lin, Zurek

g xy!wyx Ef y !Q ~



h





Τ

 \sim

Åz





$$\chi z$$
 1z q H²:: E⁷=C = 2
1 j bS1 1z q H²=?⁷=AF: B2



 $z b A R \sim z S$ R Ζ

h uw

Qu waxy

g

1

g





huu!bu !au 4MXg4gu~ !a xu4u x!fu u!Yu u Oz q H<u>AF</u>=?AAD



huu!bu !au 4MXg4gu~ !a xu4u x!fu u !Yu u Oz q HPAF7=?AAD





!TWEU yx! x ~y !z uw





Ζ

m z ~ z



Emission line spectrum with narrow lines



Gas particles with random motions



Emission line spectrum with thermal line broadening



R~EE E71u 6 6yx 6u7w

e z 6



ЕЛи 6wu6yx7 ~7Уи 5u u5zу6 e z 6




T Å z Q z



i