

Study of the $^{48}\text{Ca} + ^{249}\text{Bk}$ fusion reaction leading to element $Z = 117$: long-lived α -decaying ^{270}Db and discovery of ^{266}Lr *

J. Khuyagbaatar^{†1,2}, *A. Yakushev*², *Ch.E. Düllmann*^{1,2,3}, *D. Ackermann*², *L.-L. Andersson*¹, *M. Asai*⁴, *M. Block*², *R.A. Boll*⁵, *H. Brand*², *D.M. Cox*⁶, *M. Dasgupta*⁷, *X. Derkx*^{1,3}, *A. Di Nitto*³, *K. Eberhardt*^{1,3}, *J. Even*¹, *M. Evers*⁷, *C. Fahlander*⁸, *U. Forsberg*⁸, *J.M. Gates*⁹, *N. Gharibyan*¹⁰, *P. Golubev*⁸, *K.E. Gregorich*⁹, *J.H. Hamilton*¹¹, *W. Hartmann*², *R.-D. Herzberg*⁶, *F.P. Heßberger*^{1,2}, *D.J. Hinde*⁷, *J. Hoffmann*², *R. Hollinger*², *A. Hübner*², *E. Jäger*², *B. Kindler*², *J.V. Kratz*³, *J. Krier*², *N. Kurz*², *M. Laatiaoui*², *S. Lahiri*¹², *R. Lang*², *B. Lommel*², *M. Maiti*¹², *K. Miernik*⁵, *S. Minami*², *A. Mistry*⁶, *C. Mokry*^{1,3}, *H. Nitsche*⁹, *J.P. Omtvedt*¹³, *G.K. Pang*⁹, *P. Papadakis*⁶, *D. Renisch*³, *J. Roberto*⁵, *D. Rudolph*⁸, *J. Runke*², *K. Rykaczewski*⁵, *L.G. Sarmiento*⁸, *M. Schädel*^{2,4}, *B. Schausten*², *A. Semchenkov*¹³, *D.A. Shaughnessy*¹⁰, *P. Steinegger*¹⁴, *J. Steiner*², *E.E. Tereshatov*¹⁰, *P. Thörle-Pospiech*^{1,3}, *K. Tinschert*², *T. Torres De Heidenreich*², *N. Trautmann*³, *A. Türler*^{14,15}, *J. Uusitalo*¹⁶, *D.E. Ward*⁸, *M. Wegrzecki*¹⁷, *N. Wiehl*^{1,3}, *S.M. Van Cleve*⁵, and *V. Yakusheva*¹

¹Helmholtz Institute Mainz, 55099 Mainz, Germany; ²GSI Helmholtzzentrum für Schwerionenforschung, 64291 Darmstadt, Germany; ³Johannes Gutenberg-Universität Mainz, 55099 Mainz, Germany; ⁴Advanced Science Research Center, Japan Atomic Energy Agency, Tokai, Ibaraki 319-1195, Japan; ⁵Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA; ⁶University of Liverpool, Liverpool L69 7ZE, United Kingdom; ⁷The Australian National University, Canberra, ACT 0200, Australia; ⁸Lund University, 22100 Lund, Sweden; ⁹Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA; ¹⁰Lawrence Livermore National Laboratory, Livermore, California 94551, USA; ¹¹Vanderbilt University, Nashville, TN 37235, USA; ¹²Saha Institute of Nuclear Physics, Kolkata 700064, India; ¹³University of Oslo, 0315 Oslo, Norway; ¹⁴Paul Scherrer Institute, 5232 Villigen, Switzerland; ¹⁵University of Bern, 3012 Bern, Switzerland; ¹⁶University of Jyväskylä, 40351 Jyväskylä, Finland; ¹⁷The Institute of Electron Technology, 02-668 Warsaw, Poland

The fusion-evaporation reaction $^{48}\text{Ca} + ^{249}\text{Bk}$, was studied at the gas-filled TransActinide Separator and Chemistry Apparatus (TASCA) [1], which was significantly upgraded [2] now being able to register nuclei with half-lives from sub- μs to a few days. We observed four decay chains among them two long ones comprising seven α decays and a spontaneous fission, both chains have similar properties (Fig. 1). Our data is largely consistent with previously reported data [3] on the decay chains assigned to $^{294}117$. In addition to data from [3], a hitherto unknown α branch in ^{270}Db , which populated the new isotope ^{266}Lr , was identified. ^{270}Db with a half-life of $1.0_{-0.4}^{+1.9}$ h is the most long-lived α -decaying nucleus above No ($Z = 102$). The decay chain members from $^{290}115$ to ^{266}Lr all decay with $T_{1/2} \gtrsim 1$ s, which opens prospects for their chemical investigation and off-line studies.

We are grateful to GSI's ECR ion-source and UNILAC staff, and the Experimental Electronics Department for their continuous support of the experiment.

* This work was financially supported in part by the German BMBF (05P12UMFNE), the Swedish Research Council, the U.S. Department of Energy by LLNL (DE-AC52-07NA27344), the Laboratory Directed Research and Development Program at LLNL (11-ERD-011) and the Helmholtz Institute Mainz. This work was co-sponsored by the Office of Science, U.S. Department of Energy, and supported under U.S. DOE grants No. DE-AC05-00OR22725.

[†] J.Khuyagbaatar@gssi.de

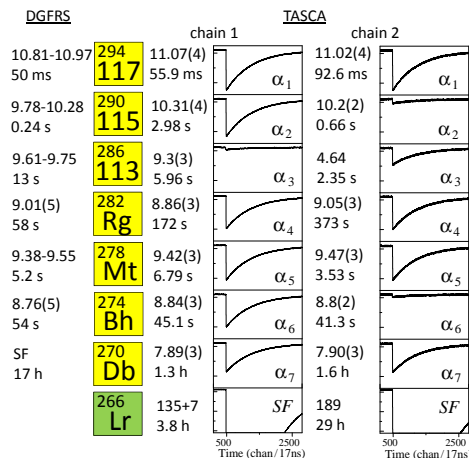


Figure 1: Decay chains assigned to $^{294}117$ from this work (together with traces of members) and data from [3].

References

- [1] A. Semchenkov et al., NIM. B **266**, 4153 (2008), J.M. Gates et al., PRC **83**, 054618 (2011).
- [2] see GSI Scientific Report-2011, pages-206, 212, 217, 218, 251-253 (2012).
- [3] Yu.Ts. Oganessian et al., PRL. **104**, 0142502 (2010), PRC. **83**, 054315 (2011), PRL. **109**, 162501 (2012), PRC. **87**, 054621 (2013).