



Exploratory Workshop Scheme

Scientific Review Group for Physical and
Engineering Sciences

ESF Exploratory Workshop on

High Energy Tidal Disruption Events: looking at the future

Favignana (Italy), 23-26 September 2013

Convened by:

Elena M. Rossi¹, Giuseppe Lodato²

¹Leiden Observatory, Leiden University, Leiden, 2333 CA, The Netherlands

²Department of Physics, Milan University, Milan, 20133, Italy

SCIENTIFIC REPORT

1. Executive summary

The meeting was held in the island of Favignana, in Italy, from the 23rd to the 26th of September 2013. There were 25 participants from 7 different countries. One third were women, which is a great success for a high energy astrophysics workshop. We aimed at an equal number of experts in theory and observations, and we favoured more junior promising participants over senior well established ones. Finally, we carefully selected participants with different and complementary expertise, so that each one could bring its unique experience and skills to the workshop. The beneficial effects of all the above choices came up particularly during the discussion sections, which were always lively and profitable.

Each day there were two sessions (morning and afternoon), each lasting for 3.5 h. The last day, the afternoon session was devoted to a final discussion and lasted a 1.5 h. Each session had a particular topic. We started with an observational overview on single events, followed by a section on surveys with current and future instruments. Once the observational state of the art was reviewed, we had the more theoretical session on modelling TDE from supermassive black holes. The sessions on the particular topics of tides in compact objects and TDE in our Galactic centre were to conclude the workshop. The final discussion on the last afternoon had the broader goal of summarise what we learnt from the workshop and how to draw future lines of development for the field. This is summarised at the end of this section, but more detailed are given on section 3.

Along the workshop, it was remarked how well prepared was each presentation, in particular those of our junior colleagues, which testified for the high quality of the speakers. Speakers also managed to engage the audience, so that almost always, the presentations were followed by many questions.

Meetings, breakfast and dinners were held in the same hotel (Hotel Cave Bianche) that provided the accommodation. This gave plenty of opportunity to informally interact outside the meeting room. At dinner, we divided the participants into 4 tables, in order to create the best condition for interaction. During the lunch breaks, participants usually divided up into smaller groups, which gave further opportunity for discussions. We believe that the meeting was a success also because the environment was pleasant and conducive to interaction. Moreover, there was the right balance for a workshop between work and moments of relax.

The workshop proceeded smoothly also because the local staff was quite supportive and organized, with long experience in managing meetings. Moreover, since the number of participants was relatively small, we could be more flexible than in a normal conference and we could accommodate for special requests/needs of the participants. Before the starting of the workshop, we could redesign the programme, so that Dr Saxton and Dr Schartmann could join us later, being delayed by personal and professional duties. Moreover, we could easily meet the necessities of two women participants, one pregnant and one with a few month old child.

The workshop's goals have been successfully achieved: astrophysicists from different communities were brought together to interact. Information was shared and a sense of belonging to a developing new field was sensed. Some collaborations started at the meeting, others were reinforced. Important open questions were identified and a clearer vision of the European facilities (current and upcoming satellites and telescopes) which are needed to address those questions was gained.

In the final discussion, we decided to repeat this experience next year, with a similar format. The TDE field is still young and therefore we did not feel the need for a larger workshop or a conference. A year time will allow us to collect new data and theoretical work to be shared.

2. Scientific content of the event

The workshop was organized into sessions with 4 presentations per session, followed by a one hour discussion, led by a “discussion leader”.

Session 1a: “Observations of specific events”

Presentation 1. A. Zauderer “Radio observations of tidal disruption events”. Zauderer discussed the modeling of radio observations of TDE, with particular emphasis on the case of Swift J1644. She also discussed the expected fraction of events that launch jets, based on a comparison with X-ray selected sources, followed up in radio.

Presentation 2. E. Troja “A candidate TDE in the Abell cluster 1795”. Troja described the evidence in favour of a TDE found in an archival search of Chandra data.

Presentation 3. R. Chornock “Pan-Starrs1 observations of TDE”. Chornock updated us on the status of the Pan-Starrs survey and the TDEs found by it. In particular, he discussed two specific events: PS1-10jh and PS1-11af.

Presentation 4. P. O’ Brien “Swift observations of relativistic TDEs”. O’Brien described mainly the case of Swift J1644 and its X-ray observations. He mentioned that Swift has now discovered what appears to be a new class of ultra-long GRB, that might be confused with TDE.

Discussion. Leader: N. Tanvir. The discussion was very lively and many different aspects were described:

-) A long discussion has focussed on the importance of high time resolution observations in order to properly identify TDEs. The case described by Troja appeared to have a lightcurve steeper than expected, but she had to extrapolate the very first data point in her UV lightcurve. It has been argued that the apparently steeper curve is an artefact resulting from this strong assumption. Troja mentioned the fact that unfortunately with archival searches there is no way to have the required high time sampling at the rise of the lightcurve. It has been suggested that automatic triggers for TDE events might enable a rapid follow up at different wavelengths.

-) The case of Swift J1644 has attracted lots of attention. Zauderer described the fact that apparently the X-ray lightcurve has suddenly dropped recently. The implications of this result have been discussed. Zauderer proposed that the jet turning off is a result of the fallback rate dropping to sub-Eddington values, but it has been noted that if that was the case, then the peak accretion rate would be extraordinarily super-Eddington, the plausibility of which remains to be understood.

-) The newly discovered ultra-long GRB found by Swift might represent a challenge in our identification of TDEs. How do we distinguish from TDEs? Could they be due to tidal disruption events as well?

Session 1b: Surveys

Presentation 1. S. van Velzen “Rate of TDE from optical survey”. Van Velzen has described the status of the search for TDE in optical surveys such as SDSS. In particular he argued that the fraction of TDE that produce a jet is less than 10% of all TDEs.

Presentation 2. S. Komossa “TDEs in X-rays and reprocessed lines”. Komossa has described X-ray observations of TDE flares in quiescent galaxies. Particular emphasis was put on emission line echoes that arise when the event occurs in a gas-rich environment.

Presentation 3. P. Jonker “Finding TDE using X-ray, optical and radio surveys”. Jonker has described a unique X-ray transient discovered in the outskirts of M86. He also discussed the

possibility of conducting simultaneous LOFAR/GAIA (and possibly Swift) observations of tidal disruption candidates.

Presentation 4. N. Blagorodnova "TDE with Gaia". Blagorodnova has described the status of the Gaia mission and its impact on TDE science. She estimates that Gaia will discover 15-40 events per year, once launched.

Discussion. Leader: E. Rossi. The discussion was extremely lively and focussed completely on Rossi's ideas about the best strategy to detect TDEs using a combination of radio and X-ray observations. Radio triggers would be used to follow up candidates with LOFT. The whole discussion was centered on whether LOFT or Athena+ would be the best X-ray missions in order to follow such a strategy.

Session 2: Theory of TDE by supermassive black holes

Presentation 1. A. King "Do jets precess". King has argued that relativistic precession will not result in jet precession, due to the fact that the disc formed in TDE would rapidly align with the black hole spin. Alternative processes for precession, like disc tearing, were also discussed.

Presentation 2. J. Cannizzo "The jetted tidal disruption event Sw1644: summary and current status". Cannizzo has described a model where the accretion rate onto the black hole actually does not follow the fallback rate, since it is mediated by viscous processes in the disc. He claimed that the lightcurve of Swift J1644 does not follow the standard $t^{-5/3}$ decay law, but a shallower $t^{-4/3}$ one, and is thus consistent with the proposed model.

Presentation 3. T. Tanaka. "Tidal disruption impostors from binary supermassive black holes". Tanaka has described how the electromagnetic emission from a binary supermassive black hole can mimic that of a TDE.

Presentation 4. R. Saxton "Distinguishing Tidal Disruption events from AGN - examples from the XMM slew survey". Saxton has shown a number of examples of variable AGN that could in principle be classified as TDE, highlighting the difficulties of a proper classification.

Discussion Leader: G. Lodato. The discussion has focussed on the current limitations of the theory of TDE. It was agreed that the most robust result about the dynamics of such events is the decline of the fallback rate as $t^{-5/3}$. What is most difficult to predict is how does this translate into a lightcurve. Thermal models for the disc emission have been developed recently, but clearly observations show that the thermal component does not appear to be cooling, contrary to the model predictions. Old models about an expanding envelope for super-Eddington events might be important in this context and need to be discussed more closely. It was agreed that Lense-Thirring precession might occur in these events, if the disc is sufficiently thick and narrow.

Session 3. Solar mass compact objects

Presentation 1. S. Rosswog "Tidal disruption of white dwarfs" Rosswog described a new method to introduce general relativistic effects in SPH simulations of tidal disruption events. He also discussed the possibility of nuclear detonation in the disruption of white dwarfs around intermediate mass black holes.

Presentation 2. M. Mapelli "Dynamics of stellar black holes in young dense star clusters: impact on X-ray binaries and gravitational waves" Mapelli described numerical simulations of the dynamics of double compact objects in stellar clusters, and discussed their formation mechanisms and fate.

Presentation 3. S. Dall'Osso "Observable tidal effects in double White Dwarfs and Neutron Stars" Dall'Osso described tidal interactions between two white dwarfs and the observational

signatures to be compared with the observation of the 12 min system. He showed that his work can constrain the amount and nature of viscosity in these stars.

Presentation 4. L. Zampieri “Variability and accretion regimes in Ultraluminous X-ray sources”. Zampieri described the observational properties of ULX and their variability. He argued that in some cases, transient ULX may indicate the presence of a TDE.

Discussion. Leader: P. O’Brien. The discussion was meant to be led by S. Campana, who could not join us. O’Brien led the discussion based on Campana’s notes. The likelihood and outcome of disruption of minor bodies, such as asteroids and planets, by stellar mass compact objects was described, in particular with reference to the case of the “Christmas burst” GRB101225A. The discussion about this object was focussed on the distinction between TDEs and ultra-long GRB, of which GRB101225A could be an example.

Session 4. The Galactic Center

Presentation 1. S. Gillessen “Watching in real-time how Sgr A* disrupts a gas cloud”. Gillessen described the status of the G2 cloud that is expected to reach pericenter around the supermassive black hole at the center of our galaxy in March 2013.

Presentation 2. M. Schartmann "Simulations of possible formation scenarios and the fate of G2". Schartmann discussed numerical simulations of the G2 cloud. Two scenarios were explored: a diffuse cloud model and a compact, mass losing object one. New 3D simulations of the first scenario were shown, that suggest that the interaction with the hot gas is less significant than in 2D, resulting in moderate accretion rates. 2D simulations of the second scenario were also presented.

Presentation 3. A. Gualandris. “Tidal disruption events in the Galactic Center”. Gualandris presented dynamical models for the formation of S2 stars in the galactic center and their connection with hyper-velocity stars, including the possibility of having an intermediate mass black hole.

Presentation 4. S. Kobayashi. "The tidal disruption of stars and binaries by a massive black hole". Kobayashi discussed general relativistic simulations of deeply penetrating events, discussing in particular the possibility of tidal detonation of the star. the gravitational wave signal expected in these cases was also discussed.

Discussion. Leader: A. King. The discussion was focused on what can we learn about TDEs from the observations of the G2 cloud. While it appeared to be relatively clear that the release of accretion energy after disruption is not going to be substantial, the important role of the ambient gas in determining the fate of the debris is something new that we learned already from this event.

3. Assessment of the results, contribution to the future direction of the field, outcome

Future of community:

- 1) We believe this topic can develop into a sub-field of astronomy in its own right. However, this is going to happen over a timescale of a few years, since we have to wait for new data (e.g. the launch of GAIA, new X-ray missions, completion of LOFAR, etc.).
- 2) We all agreed about the need for a regular (for example, yearly) meeting, to strengthen a sense of a community and discuss new results.

Funding instruments:

- 1) We plan to use again the ESF, but most likely for smaller workshops of the kind of the Favignana one. The rationale is connected to the expected growth rate of the community

over short timescales, discussed above. This year we will see the launch of GAIA, and new X-ray missions like LOFT and Athena+ will be evaluated soon. Extrapolating the current rate of event detections, we estimate that most of the data will come along over a timescale of a few years and at that time we can expect a significant growth.

2) We also plan to use other funds at the national level: for example, the British Royal Society has been mentioned, as well as the Dutch Lorenz Center. We could use these two funding bodies to organize small/medium sized meetings.

Strategy for the future:

1) The workshop has stimulated several collaborations between the participants. At this stage we think that spontaneous collaborations, possibly strengthened by regular small sized meetings, could be the best strategy.

2) Visits and exchanges have also been discussed and were agreed on during the meeting, some of which have already started.

3) In the attached pdf slides, there are also the main scientific questions that we plan to address in the future.

Scientific open questions:

In the course of the workshop we identified the important open questions to be addressed in the coming year. First of all, we need to identify TDEs unambiguously. Both observationally and theoretically, we need to identify a smoking gun. Theoretically, most effort in recent years have been devoted to dynamics, but in the future more work should be invested in the modelling of the radiation properties. Observationally, we are still lacking a coordination of observations at different wavelengths, as done in more mature fields, such as gamma-ray bursts. We should also be open to new observational diagnostics, such as spectroscopy of lines, since so far we have been concentrated to detecting lightcurves.

It has been agreed to meet again in a year time to share our progress. Since the field is young, we prefer people to follow the spontaneous collaborations that were born during the meeting. The field is not mature yet for a more organized form of collaboration. Next year, during the next meeting, we may judge the time ripe and decide to build a European Network, using ESF or other European fundings.

4. Final programme

Monday 23 September 2013

Afternoon	Arrival
20.00	Dinner

Tuesday 24 September 2013

09.00-09.10	Welcome by Convenors	E.M. Rossi & G. Lodato
09.10-09.30	Presentation of the ESF	David Blaschke
09.30-12.30	Morning Session: Observations of specific events	
09.30-10.00	“Radio observations of TDEs”	A. Zauderer
10.00-10.30	“A candidate TDE in the Chandra fields of abel 1795”	E. Troja
10.30-10.45	Coffee / Tea Break	
10.45-11.15	“Pan-Starrs1 observations of TDE”	R.Chornock
11.15-11.45	“Recent Swift observations of TDEs”	P. O’Brien
11.45-12.30	Discussion “What should be trying to observe in a single event and how?”, discussion leader: N. Tanvir	
12.30-15.30	Lunch	
15.30-19.00	Afternoon Session: Survey	
15.30-16.00	“Deriving the rates of optical TDEs from SDSS”	S. van Velzen

16.00-16.30 "TDEs in X-rays, and reprocessed emission lines" S. Komossa
16.30-17.00 Coffee / tea break
17.00-17.30 "Finding TDEs using X-ray, optical and radio survey" P. Jonker
17.30-18.00 "TDEs with Gaia" N. Blagorodnova
18.00-19.00 Discussion "How can we collect a significant sample? in which bands? how can we understand the completeness of a survey?" Discussion leader: E. Rossi

20.00 Dinner

Wednesday 25 September 2013

09.00-12.30 Morning Session: Dynamics and emission properties of TDE
09.00-09.30 "Do jets precess?" A. King
09.30-10.00 "The jetted TDE Sw1644:summary and current status" J. Cannizzo
10.00-10.30 Coffee / Tea Break
10.30-11.00 "TD impostors from binary supermassive black holes" T. Tanaka
11.00-11.30 "Distinguishing TDEs from AGN: examples from XMM slew survey" R. Saxton
11.30-12.30 "What should be the priorities for theoretical modelling in order to predict robust observables?" Discussion Leader: G. Lodato

12.30-15.30 Lunch

15.30-19.00 Afternoon Session: Solar mass compact Objects
15.30-16.00 "Tidal disruption of white dwarfs" S. Rosswog
16.00-16.30 "Dynamics of stellar black holes in young dense star clusters: impact on x-ray binaries and GWs" M. Mapelli
16.30-17.00 Coffee / Tea Break
17.00-17.30 "Observable tidal effects in double White Dwarfs and Neutron Stars" S. Dall'Osso
17.30-18.00 "Variability and Accretion regimes in Ultraluminous X-ray sources" L. Zampieri
18.00-19.00 Discussion : "What are the prospects and developments for TDEs on smaller scales?" P. O'Brien

20.00 Dinner

Thursday 26 September 2013

09.00-12.30 Morning Session: The Galactic Centre
09.00-09.30 "Watching in real time how SgrA* disrupts a gas cloud" S. Gillessen
09.30-10.00 "Simulations of possible formation scenarios and the fate of G2" M. Schartmann
10.00-10.30 Coffee / Tea Break
10.30-11.00 "Tidal disruption events in the Galactic Center" A. Gualandris
11.00-11.30 "The tidal disruption of stars and binaries by a massive black hole" S. Kobayashi
11.30-12.30 Discussion : "What general lesson do we learn from our Galactic Centre? Can we predict reliable rates?" A. King

12.30-15.00 Lunch

15.00-16.00 Afternoon Session: Final discussion (leaders Rossi & Lodato):
-How to exploit the European expertise and facilities, to increase the detection rate of TDE and extract the most interesting physical information
- How to structure and organize the European Community and create bridges between theory and observations

16.00 End of the workshop

5. Final list of participants

1. Elena Rossi (Leiden Observatory)
2. Giuseppe Lodato (University of Milano)
3. Marc Schartmann (MPE Garching)
4. Paolo D'Avanzo (Brera Observatory)
5. Stefanie Komossa (MPIfR Bonn)
6. Alessia Gualandris (Leicester University)
7. Andreja Gomboc (University of Ljubljana)
8. Simone Dall'Osso (University of Tuebingen)
9. Peter Jonker (SRON)
10. Richard Saxton (ESA)
11. Paul O'Brien (Leicester University)
12. Stephan Rosswog (Jacobs University Bremen)
13. Takamitsu Tanaka (MPA Garching)
14. Nial Tanvir (Leicester University)
15. Sjoert van Velzen (Radboud University Nijmegen)
16. Luca Zampieri (Padova Observatory)
17. Ashley Zauderer (CfA, Harvard)
18. Nadia Blagorodnova (University of Cambridge)
19. Stefan Gillessen (MPE Garching)
20. Andrew King (Leicester University)
21. Shiyo Kobayashi (Liverpool John Moores University)
22. Michela Mapelli (Padova Observatory)
23. Eleonora Troja (NASA)
24. John Cannizzo (NASA)
25. Ryan Chornock (CfA, Harvard)

An additional participant, Sergio Campana, had to cancel the day before the start of the meeting, so we had to pay his room charges due to no show.

6. Statistical information on participants

Age bracket:
29-65

M/F repartition:

Male	68%		Female	32%
------	-----	--	--------	-----

Geographical distribution

Country of origin	Number of participants	%
UK	7	28%
Germany	6	24%
Italy	4	16%
Netherlands	3	12%
Slovenia	1	4%
USA	4	16%

(Note: three participants from the USA were supported through our additional funding from the University of Milano)

Repartition by scientific speciality:

Theory	12	(48%)
Observations	13	(52%)